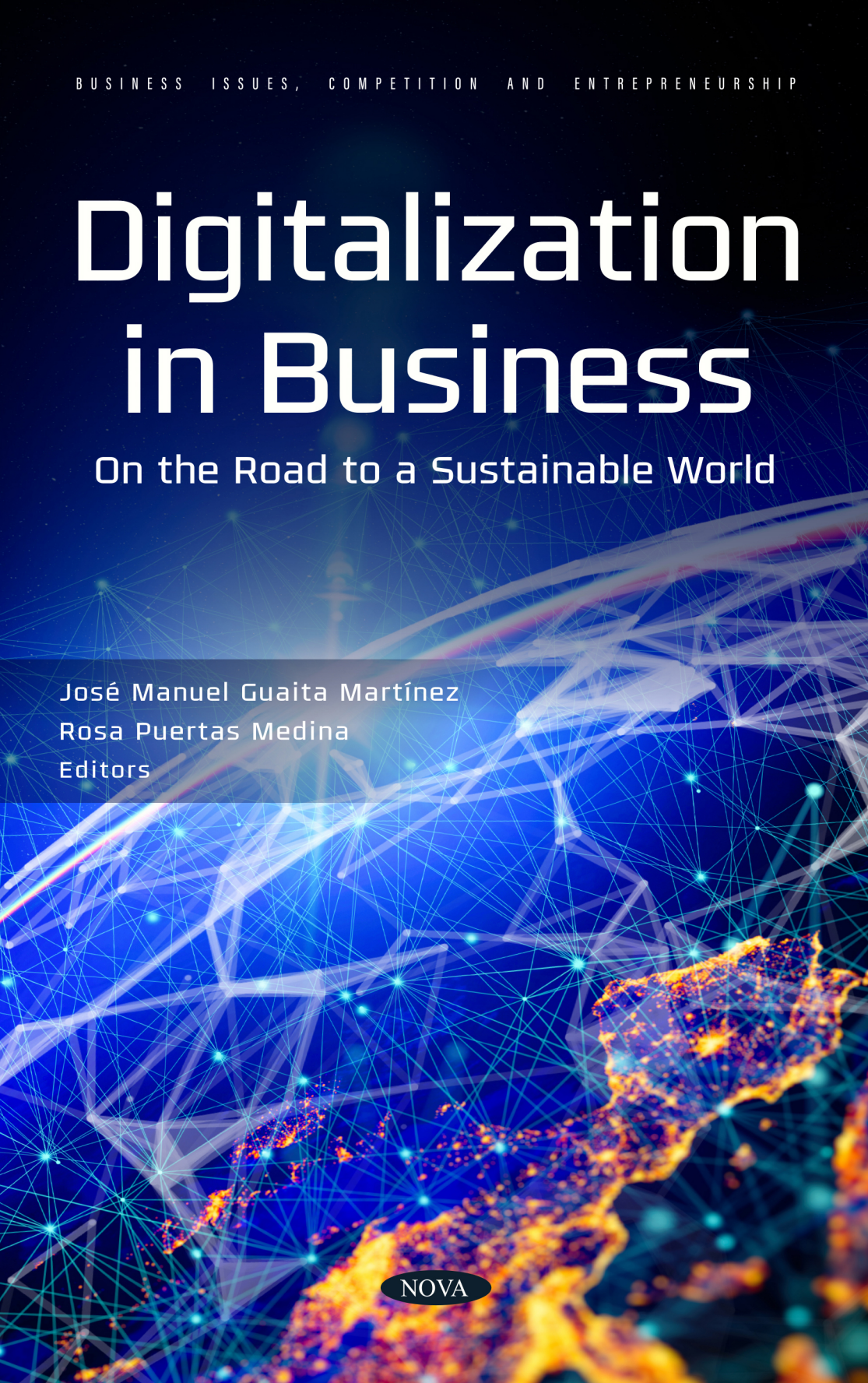
BUSINESS ISSUES, COMPETITION AND ENTREPRENEURSHIP

Digitalization in Business

On the Road to a Sustainable World

José Manuel Guaita Martínez
Rosa Puertas Medina
Editors



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and Rosa Puertas Medina, PhD
Editors

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Preface

In recent decades, all sectors of society and the economy have been forced to adapt to the continuous advances of the digital age. These new technologies are bringing about changes in how we communicate, work and even live, offering opportunities to face future challenges. The concept of digitalization is a fundamental part of the economic catharsis of the 21st century.

The book presented here captures some aspects of this great transformation, revealing how digitalization impacts all levels of society and the economy. The need for innovation, the efficiency of its implementation, the effects on tourism and trade, its implementation in culture, and the possible gender gap associated with its development, are crucial elements analyzed in the chapters that make up this book. The results will provide evidence that decision-makers can use to achieve a homogeneous evolution of this great transformation, guaranteeing the success of the measures adopted.

Chapter 1

Analysis of the Efficiency of Digitalization in European Union Countries

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Abstract

The advance of digitalization has brought to light the pressing need to adapt to new technologies that are permeating into all socioeconomic strata. Humanity has no choice; it must adjust in order to survive. Digitalization is shaping all facets of society, education, health, business activities, consumer behavior, and so on. It is a process that has become the driving force of globalization, helping to break down barriers and reduce distances between nations. The acceptance and assimilation of digitalization bring with it important changes, in which training the population plays a relevant role. Businesses require a trained workforce to ensure the correct use of these new technologies and maximize their usefulness, guaranteeing firms a key differentiating position in world markets.

This research involves a detailed study of the situation in Europe, analyzing the efficiency of digital resources in four western EU countries that are the European gateway to trade with Africa—namely, Portugal, Spain, France and Italy— over a seven-year period (2014-2020). Regarding the methodology, variants of data envelopment analysis (DEA) are used to carry out an exhaustive analysis of all the stages of the process; specifically, DEA-Bootstrap, the Malmquist Index and non-

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concave metafrontiers. Based on the results, a number of important conclusions have been drawn that can help decision-makers when developing investment policies: (1) digitalization is not found to be even across all territories; (2) countries have targeted their efforts at introducing technological advances, disregarding the improvements in efficiency that could be achieved through more training for society, (3) regions in France are adapting best to this new situation, while Italy is the least efficient. These days, the level of digitalization conditions economic growth and even the sustainable development of humanity; hence, there is a need to achieve homogeneous implementation of these emerging, cutting-edge technologies.

Keywords: Western European Union, digitalization, data envelopment analysis, efficiency, Malmquist index

Introduction

The terms digital transformation, digitization and digitalization are sometimes used interchangeably to define innovative technologies, overlooking the distinctions between them (Caputo et al., 2021). They all describe a transformative new way of conducting economic and social relations that minimizes cultural barriers (Mugge et al., 2020). A literature addressing these concepts has emerged in recent years, in which the perspective of digital change focused on specific business disciplines has given way to a multidisciplinary issue affecting all socioeconomic strata (Schallmo and Williams, 2018; Verhoef et al., 2021).

In the business field, digital transformation, also called digitalization 4.0, ensures flexible business models and accurate analyses grounded in data science. It represents the key to bolstering competitiveness, improving procedures and securing a position in international markets (Llopis-Albert et al., 2021). The connection with the other terms (digitization and digitalization) hinges on the fact that its implementation requires organizational changes made through digitalization projects (Warner and Wäger, 2019). It is a continuous process that involves the use of artificial intelligence, blockchain, internet of things (IoT) and even mobile telephony in order for companies to optimize their performance while improving the service offered to customers.

The distinction between digitization and digitalization is even harder to pin down, since some languages such as Spanish, German or Japanese do not distinguish between the two (Vrana and Singh, 2021). The first term is defined

as the transformation of analogue information into digital information, whereas digitalization is a much broader concept involving the integration of digitized information into a socioeconomic context, simplifying daily operations (Bloomberg, 2018). Despite these nuanced differences, however, the two notions are closely related: both digital transformation and digitalization require digital information to guarantee the success of their implementation. The nexus between the three has contributed to the achievement of previously unimaginable advances in education (Komarova et al., 2022), tourism (Xiang, 2018), healthcare (Lapão, 2019), industry (Papadopoulos et al., 2022) and, above all, trade relations (Katz et al., 2020; Hope and Campbell, 2021).

In short, the process leading to the worldwide digitalization of the economy and society requires the implementation of new technologies that facilitate not only access to information but also connectivity between all available services. It is about being able to offer people a general-purpose technology that facilitates even their daily activities, while being compatible with ethical and sustainability principles (Matt et al., 2022). COVID-19 has changed society's priorities, underscoring the importance of the digital age and the need to achieve homogeneous development across all countries to ensure the safety of the population (Amankwah-Amoah et al., 2021). Against this backdrop, the present research seeks to provide quantitative evidence on the current level of digital progress by assessing the situation in this regard of four European countries—Portugal, Spain, France and Italy—in the period 2014-2020. Specifically, a regional analysis is conducted to provide answers to the following research questions:

Q1. Is there a clear difference between regions in terms of the efficiency of digitalization in the analyzed countries?

Q2. Have there been any improvements during the period analyzed? What is the source of these improvements?

Q3. Is there a technology gap between the analyzed countries?

These questions will be answered using variants of data envelopment analysis (DEA); specifically, intertemporal DEA-Bootstrap, the sequential Malmquist Index (MI) and a non-concave metafrontier. These methods are used to provide concise answers to each question, in order to gain an understanding of the situation and guide future technological investment measures that guarantee uniform digital development and ensure the connectivity of society. DEA has been used to analyze the effects of

digitalization in different areas such as banking (Ekinci, 2021), energy (Zhao et al., 2021), culture (Raimo et al., 2021), the agri-food industry (Annosi et al., 2020), as well as to assess the relative efficiency of the digital transformation in the EU (Inel, 2019) or in developing countries (Gebre-Mariam and Bygstad, 2019). This research helps to fill the gap in the literature by offering a detailed regional analysis of the progress achieved, from various perspectives, yielding accurate information on the current situation. Specifically, this study makes the following contributions: (1) the regional perspective enables policies to be focused on the territories that are lagging behind; (2) the length of the period of analysis allows an assessment of the development achieved over the economic cycle, presenting evidence on aspects to be improved; (3) the intertemporal analysis prevents possible outliers from affecting the results; (4) the identification of a technology gap allows the modeling of a pattern to be followed by the other regions; (5) the recency of the period under study means policymakers can draw conclusions based on the current state of the issue, thus providing a useful decision-making tool.

The rest of the chapter is structured into the following sections. Section 2 presents the framework for the study carried out. Section 3 presents the methods and the sample used in the empirical analysis. Section 4 discusses the results that provide answers to the questions raised. Finally, section 5 summarizes the main conclusions of the research and its possible limitations.

Framework of EU Digitalization

In order for digitalization to be consolidated, digital technologies must be incorporated into the everyday life of society and organizations; these instruments must be used daily and the user must perceive them to be useful. This a key factor in countries' economic growth (Yuan et al., 2021). Industry 4.0, conceived of as a combination of new technologies integrated into all levels of the economy, has accelerated digitalization (Han et al., 2021). It is a new approach in a scenario where companies and customers interact with each other in real time, and its implementation is improving supply chains, transforming products and market expectations. Lioutas et al. (2021) show that digitalization has social, cultural, political and environmental effects, and is even a suitable instrument for tackling food problems.

In this context, the impact on the labor market has not taken long to materialize; new skills are required to address the needs that the use of these

emergent technologies entails (Fromhold-Eisebith et al., 2021). Seeking to address possible deficiencies, the European Commission has coined the term Industry 5.0 as a complement to the notions implicit in Industry 4.0, with the idea that industrial development should promote both economic growth and sustainable practices (European Commission, 2021a). Industry 5.0 shines a light on the importance of the human factor, emphasizing that technology should serve people and not vice versa. The digital transformation, aimed at both automation and providing answers to consumers' diverse demands, also requires a consideration of the possible link between the role of workers and the new digital techniques (Kumar et al., 2021).

This know-how is permeating into people's homes, triggering important changes in ways of living and working. However, the proper implementation of digitalization requires specific digital skills, which facilitate the execution of innovative processes in businesses. In 2021, the EU established Europe's Digital Compass, the content of which is centered around four key points that translate into objectives to be achieved in the decade to 2030 (European Commission, 2021b):

1. Ensuring that the percentage of European citizens lacking digital skills does not exceed 20%; the currently figure is 42%. This will entail promoting the training of specialists in information and communication technology (ICT).
2. Installing secure, performant and sustainable digital infrastructures to ensure the connectivity of all households. One aim is for European semiconductor production to account for 20% of global production.
3. Promoting the digital transformation of businesses, with the aim of three out of four using digital models.
4. Achieving the total digitalization of public services.

In order to unify positions, in January 2022 the European Commission proposed a project on digital rights and principles (European Commission, 2022). The stated priority in this declaration is that people should be placed at the center of the process, while at the same time incentivizing innovative companies. According to the published document, the digital transformation of the EU "should encompass digital sovereignty, inclusion, equality, sustainability, resilience, security, trust, improving quality of life, respect of people's rights and aspirations and should contribute to a dynamic, resource-efficient and fair economy and society in the Union."

The scientific community's notable research output on the analysis of digitalization in EU member countries is unprecedented. For example, Grigorescu et al. (2021) analyze the possible correlation between the well-being of the population and digitalization, demonstrating that the advances achieved translate into greater satisfaction for citizens. The desired efficient competitiveness will only be within reach of those businesses that have definitively opted for digitalization; indeed, it is one of the most influential factors in competitiveness in European countries, second only to macroeconomic stability (Boikova et al., 2021). Furthermore, it has been shown that digital technologies are changing the movement of people and goods through different territories, with the consequent energy and environmental impact. Noussan and Tagliapietra (2020) evaluate the effect on energy consumption of digitalization in transport, determining the variability range of this effect in a future scenario between 2030 and 2050.

All these changes have been accelerated by COVID-19, revealing existing weaknesses and highlighting the need to update procedures at all levels (Chopra et al., 2022). These unprecedented activities are here to stay; they have transformed the way of working, learning, socializing, and buying and selling goods and services of all kinds (Cone et al., 2021; Polycronidou et al., 2021; Wang et al., 2021; Guaita et al., 2022). According to Elmassah and Hassanein (2022), the pandemic has hastened the implementation of digital technologies to facilitate the organization of work, falling into a loop of socioeconomic costs and opportunities that require special attention. Efforts must be made to ensure work-life balance for workers. In this regard, Nell et al. (2021) point out that the benefits of digitalization sometimes have unintended effects on the organizational design of companies, empowering senior managers and giving them the ability to intervene in even the most routine operations.

However, this macro revolution will not be possible without the financing to support the necessary changes. In the period 2016-2022 alone, the EU has allocated 192 million euros to finance the digital transformation of agriculture, and has also had to maintain and expand the budget allocated to the modernization of society and businesses. In parallel, the NextGenerationEU program, developed to mitigate the economic effects of COVID-19, is based around four cross-cutting goals: ecological transition, digital transformation, social and territorial cohesion, and gender equality. It is a recovery plan involving the investment 750 billion euros (2018 prices), aimed not only at stimulating the economy but also at achieving a more ecological, digital and resilient Europe (European Commission, 2021c). Balsmeier and Woerter

(2019) have found evidence of the positive effect of such investment on the employment of highly qualified people. Furthermore, according to Eller et al. (2020), more intense digitalization boosts financial performance as long as it is accompanied by more employee training and a proper digital strategy.

Methods and Materials

We provide answers to the proposed research questions by carrying out an empirical analysis of the regions of four western EU countries, covering a seven-year period (2014-2020) that incorporates the possible effect of the pandemic. Specifically, the sample is made up of 7 regions in Portugal, 19 in Spain, 22 in France and 21 in Italy. The research takes an intertemporal approach, which helps to ensure the robustness of the results (Bresciani et al., 2021; Puertas et al., 2022). The methods used are supported by ample literature in which DEA-Bootstrap and the MI have been used to address issues relating to climate change mitigation (Puertas and Marti, 2021), the implementation of innovative processes in Europe (Carracedo and Puertas, 2022) and even in assessments related to water (García-Mollá et al., 2021; de Castro-Pardo et al., 2022). On the other hand, metafrontiers have been successfully used to identify the technology gap in various productive sectors such as energy (Yu et al., 2019), the shadow price of carbon (Shen et al., 2021), irrigation infrastructures (Bravo-Ureta et al., 2020), and the water-energy nexus (Ding et al., 2020), among others.

Methods

DEA-Bootstrap, MI and Non-Concave Metafrontier

DEA is a non-parametric technique used to calculate the efficiency of homogeneous decision units (DMUs) defined by the same inputs and outputs. DEA identifies the optimal combinations of factors used to generate the desired quantity of output, thus defining an efficient frontier. The distance from this frontier represents the degree of inefficiency. Charnes et al. (1978) defined the DEA model under the assumption of constant returns to scale (CCR model); that is, supposing proportional changes in inputs and outputs. Responding to the need to make the model more flexible, Banker et al. (1984) proposed the introduction of variable returns to scale (BCC model) in order to

be able to account for and assess the possible inefficiencies caused by inappropriate size. The definition of the BCC model allows for two orientations: an input-oriented model, where the aim is to minimize the resources used to obtain the desired output; and an output-oriented model, where the aim is to maximize the output obtained with the available inputs. The choice of orientation depends on the requirements of the problem posed. The popularity of this method is mainly due to the ability to examine the multiple aspects that characterize the observations of the sample, and the flexibility of not having a pre-established functional form. However, the results are strongly conditioned by the choice of inputs and outputs, and there is no test to determine their appropriacy.[1]

This research uses DEA-Bootstrap, where the optimization procedure is performed iteratively yielding more accurate results. It was suggested by Simar and Wilson (2007) as a way of increasing the initial number of observations and correcting certain dimensionality problems (Simar and Zelenyuk, 2011). The corrected efficiency levels and confidence intervals are calculated through a data-generating process; specifically, 2000 iterations have been performed. Depending on the orientation of the problem posed, the results have different bounds. The analysis has been carried out under the BCC approach, with an output orientation, such that those DMUs scoring a value of 1 are completely efficient, and an amount over 1 represents how much the outputs need to increase by to reach the frontier. In addition, the analysis is of an intertemporal nature, involving the calculation of country-specific efficient frontiers covering the entire study period. This makes it possible to look for similarities between regions in the same country. If a frontier were calculated for each country and year, the results would not be comparable, even if they belonged to the same country (Puertas et al., 2020). Therefore, each region is evaluated in comparison with the rest of the observations that make up the sample, without differentiating by time. In this way, the efficiency level of each DMU is calculated as the mean of the efficiency achieved in the years corresponding to the analyzed period.

Changes in productivity have been calculated using the sequential MI. It was originally proposed by Caves et al. (1982), with Färe et al. (1989) later suggesting the decomposition into changes in technical efficiency (EC) and changes in technology (TC), depending on the source of the change. Its measurement involves identifying changes in the use of inputs and outputs by

[1] All efficiency calculations were done using the deaR statistical package implemented in Rstudio (Coll et al., 2018).

DMUs, relative to the efficient frontier, between two sequential moments in time, t and t + 1. Again, either an input or an output orientation can be adopted, and the results are not bounded: values below 1 represent productivity losses, while values above 1 indicate the progress achieved. In this study, sequential MI is calculated to avoid having to consider technological regress when values of less than 1 are obtained for TC (Tulkens and Eeckaut, 1995). Therefore, innovation is viewed as additive in nature, with it being possible to obtain values equal to 1 when no technological advances have been made, or higher than 1, where the amount over 1 represents the innovation achieved during the analyzed period.

Finally, in order to answer the third research question, the metafrontier is used to determine which territory best manages digitalization, in turn achieving higher levels of efficiency. Originally proposed by Hayami (1969) and Hayami and Ruttan (1970, 1971), it can be estimated under a stochastic approach (Battese and Rao, 2002; Battesse et al., 2004) or a non-parametric one (Eguchi et al., 2021; Chang and Tovar, 2021), with the latter being the one that has become most popular. It consists of calculating an efficient frontier for each country as well as a global one that envelops them all. Thus, the following calculation must be performed for each observation:

- The distance to its own frontier (TEk). This determines the level of efficiency of each observation in comparison with the DMUs from the same country.
- The distance to the envelope frontier, called the metafrontier (TE). It constitutes the level of efficiency in relation to the group of countries considered.
- The ratio between TE and TEk formalizes the ratio that determines the technology gap with respect to the best positioned (TGR).

$$TGR_i = \frac{TE_i(x,y)}{TE_i^k(x^k,y^k)} \quad (1)$$

where $TE_i(x, y)$ represents the technical efficiency of DMU i calculated with respect to the metafrontier; $TE_i^k(x^k, y^k)$ the efficiency of DMU i in group k to which it belongs; and TGR_i is the Technology Gap Ratio. According to O'Donnell et al. (2008) this ratio provides valuable information by allowing the TE components to be analyzed individually.

$$TE_i(x,y) = TE_i^k(x^k,y^k) \cdot TGR_i \quad (2)$$

Therefore, equation (2) shows that the technical efficiency of each DMU with respect to the metafrontier (TE) is composed of the level of efficiency achieved within its group (TEk) and the distance between the group-specific frontier and the metafrontier, that is, the gap that exists as a result of the way the activity is managed (TGR).

The curve of the individual frontiers means the metafrontier encompasses combinations of input and outputs that could not possibly occur in the analyzed sample, with this area forming a triangle known as the "infeasible input-output combinations" (O'Donnell et al., 2008; Tiedemann et al., 2011). Accordingly, in this study we estimate a non-concave metafrontier in order to perfectly fit the frontier to the profile of possible efficient combinations (Sala-Garrido et al., 2011).

Materials

The efficient frontiers calculated to answer the research questions have been constructed based on the resources and products representative of the digitalization of the analyzed regions. Table 1 defines the 3 inputs and 5 outputs used in the empirical analysis, all of which have been extracted from the Eurostat database.

Table 1. Variables used for the DEA techniques applied (%)

Variable	Role	Definition
Internet	input	Households with internet access
Broadband	input	Households with broadband access
Frequency	input	Frequency of internet access: once a week
Networks	output	Creating user profile, posting messages, Facebook, Twitter, etc.
Authorities	output	Using the internet for interaction with public authorities
Purchase	output	Last online purchase: in the 12 months
Selling	output	Selling goods and services
Banking	output	Internet banking

Source: Own elaboration.

The use of these variables is supported by a robust literature, demonstrating their suitability for assessing digitalization performance (Ekinci, 2021; Yalçin, 2021; European Commission, 2021d). The different DEA models proposed have been defined in an output-oriented BCC setting, meaning the aim is to maximize the output with the available resources. Table

2 shows the descriptive statistics of all the variables corresponding to the mean of the regions in Spain, Portugal, France and Italy.

Table 2. Descriptive statistics of the analyzed countries (2014-2020)

	Internet	Broadband	Frequency	Networks	Authorities	Purchase	Selling	Banking
Spain								
Mean	84.29	83.58	79.90	55.28	53.11	48.44	11.30	45.96
SD	7.47	7.98	7.45	6.65	6.59	10.31	3.15	10.18
Max	99	99	94	78	71	71	28	75
Min	67	62	64	40	42	25	3	27
Nº obs.	133	133	133	133	133	133	133	133
Portugal								
Mean	75.94	74.16	69.47	56.12	40.73	34.88	7.82	33.39
SD	8.70	8.46	7.11	6.96	7.27	6.78	2.04	9.32
Max	91	89	84	67	61	52	13	56
Min	54	53	55	41	32	21	5	20
Nº obs.	49	49	49	49	49	49	49	49
France								
Mean	85.74	78.20	82.59	40.03	67.16	66.19	25.12	61.30
SD	5.28	5.39	4.75	5.21	7.39	5.75	4.81	6.31
Max	95	92	91	54	82	78	37	74
Min	58	57	59	13	43	48	4	35
Nº obs.	154	154	154	154	154	154	154	154
Italy								
Mean	80.27	78.71	68.57	41.96	24.93	33.23	8.65	31.71
SD	6.78	6.87	8.10	5.15	5.55	10.06	2.44	9.85
Max	93	93	85	56	41	55	17	55
Min	63	61	48	31	14	10	3	13
Nº obs.	147	147	147	147	147	147	147	147

Source: Own elaboration.

These results show a clear differentiation between the countries analyzed. In Spain, Portugal and Italy, broadband is widespread, in that almost all individuals with internet access have broadband, whereas in France there is a difference of more than 7 percentage points. In Spain, the maximum values of the three inputs considered are close to 100%, with these figures being slightly lower in the other countries, while the minimum values are around 55%-65%. All this shows that these new technologies, despite the difficulties involved in their development and adaptation, are reaching every home. However, the level of outputs shows the need to provide the population with more training

to boost the uptake of these new technologies to deal with day-to-day tasks, an issue closely related to the problem of the digitalization of the elderly. Despite the available resources, there are still regions in Spain where the use of internet banking and online buying or selling barely exceed 23%, 25% and 3%, respectively, with similar results found in the other countries.

Result and Discussion

Q1. Is there a clear difference between regions in terms of the efficiency of digitalization in the analyzed countries?

Answering this question requires the estimation of the intertemporal DEA-Bootstrap, constructing a country-specific efficient frontier from regional statistical information covering the seven years of the analyzed period. Although it is not possible to make comparisons between countries in terms of efficiency levels achieved as they have different efficient frontiers, the results will be very useful for determining whether there are some regions that are lagging behind in terms of digitalization. The columns of Table 3 show the mean efficiency values (EFF_level mean) and the standard deviation (EFF_level SD). In addition, the regions have been grouped by zones in order to provide a more consistent view across countries.

As shown in Table 3, we do not observe a homogeneous pattern in the analyzed countries, except in France, where on average the regions of the three zones need only increase their outputs by 5% to be completely efficient, showing an even performance across the entire country (Q1). In Spain, the North and Centre regions reveal very similar levels of efficiency (1.090 and 1.093, respectively), with the figure rising to 1.121 in the South and Islands. However, in Portugal and Italy it is the Centre that shows the best performance followed by the South and then the North. For example, in the North in Italy, output could be increased by more than 10% using the available resources. This analysis provides quantitative data on the level of digitalization of the different regions, which can help guide investment efforts towards the areas that are lagging behind, such as Southern Spain, Northern Italy or Northern Portugal.

Table 3. Regional efficiency levels estimated using DEA-Bootstrap (2014-2020)

SPAIN			ITALY			FRANCE			PORTUGAL		
DMU	*EFF_ level mean*	*EFF_ level SD*	*DMU*	*EFF_ level mean*	*EFF_ level SD*	*DMU*	*EFF_ level mean*	*EFF_ level SD*	*DMU*	*EFF_ level mean*	*EFF_ level SD*
NORTH											
Galicia	1.091	0.033	Piemonte	1.108	0.049	Île de France	1.050	0.022	Norte	1.072	0.039
Asturias	1.121	0.055	Valle d'Aosta	1.059	0.011	Alsace	1.056	0.033			
Cantabria	1.104	0.060	Liguria	1.119	0.072	Champagne-Ardenne	1.042	0.021			
País Vasco	1.089	0.030	Lombardia	1.115	0.033	Lorraine	1.068	0.032			
Navarra	1.064	0.031	P.A. Bolzano	1.137	0.057	Picardie	1.052	0.035			
La Rioja	1.119	0.070	P.A. Trento	1.072	0.031	Basse-Normandie	1.079	0.050			
Aragón	1.079	0.034	Veneto	1.134	0.065	Haute-Normandie	1.033	0.012			
Cataluña	1.051	0.022	Friuli-Venezia Giulia	1.106	0.055	Nord-Pas-de-Calais	1.040	0.026			
			Emilia-Romagna	1.104	0.049	Bretagne	1.051	1.051			
Mean	1.090	0.042	Mean	1.106	0.047	Mean	1.052	0.143	Mean	1.072	0.039
CENTRE											
C. Madrid	1.058	0.027	Toscana	1.054	0.030	Centre - Val de Loire	1.085	0.031	Centro	1.039	0.020
Castilla y León	1.123	0.044	Umbria	1.075	0.041	Bourgogne	1.047	0.023	Á.M. de Lisboa	1.026	0.005
Castilla-Mancha	1.107	0.044	Marche	1.083	0.044	Poitou-Charentes	1.038	0.034	Alentejo	1.031	0.013

Table 3. (Continued)

SPAIN			ITALY			FRANCE			PORTUGAL		
DMU	*EFF_ level mean*	*EFF_ level SD*	*DMU*	*EFF_ level mean*	*EFF_ level SD*	*DMU*	*EFF_ level mean*	*EFF_ level SD*	*DMU*	*EFF_ level mean*	*EFF_ level SD*
CENTRE											
Extremadura	1.075	0.039	Lazio	1.066	0.047	Pays-de-la-Loire	1.050	0.026			
C. Valenciana	1.100	0.034	Abruzzo	1.092	0.045	Franche-Comté	1.050	0.024			
			Molise	1.059	0.030	Limousin	1.047	0.028			
						Rhône-Alpes	1.035	0.022			
						Auvergne	1.084	0.059			
Mean	1.093	0.037	Mean	1.072	0.040	Mean	1.054	0.143	Mean	1.032	0.039
SOUTH AND ISLANDS											
Illes Balears	1.058	0.036	Campania	1.088	0.037	Aquitaine	1.044	0.031	Algarve	1.056	0.030
Andalucía	1.106	0.047	Puglia	1.112	0.054	Languedoc-Roussillon	1.052	0.036	R.A. dos Açores	1.049	0.036
Murcia	1.168	0.037	Basilicata	1.068	0.038	Midi-Pyrénées	1.037	0.027	R.A. Madeira	1.054	0.037
Ceuta	1.081	0.037	Calabria	1.096	0.050	Provence-Alpes-Côte d'Azur	1.069	0.016			
Ciudad de Melilla	1.148	0.129	Sicilia	1.069	0.043	Corse	1.060	0.054			
Canarias	1.166	0.070	Sardegna	1.059	0.038						
Mean	1.121	0.060	Mean	1.082	0.043	Mean	1.052	0.033	Mean	1.053	0.035

Source: Own elaboration.

The need to achieve proper digitalization in all countries lies in its proven contribution to economic growth (Godwin et al., 2020) and to the improvement of labor productivity in businesses (Cette et al., 2021). However, it has not yet been possible to decouple said growth from energy consumption (Ren et al., 2021). Although ICT represents a tool that can be used to boost energy efficiency, the sector itself is fairly energy intensive, sparking much debate in the scientific community, where there is widespread support for global sustainable development (Lange et al., 2020). Previous studies conducted have focused on the sample countries: Portugal, seeking to clarify the role of local authorities in digital transformations (Rodrigues and Franco, 2021); Spain, reporting evidence of the link between employment and digitalization (Enciso-Santocildes et al., 2021); Italy, assessing digital platforms targeted at business process management, showing the improved performance of the sea-land supply chain, as well as interorganizational relationships (Di Vaio and Varriale, 2020); and France, examining the relationships between digitalization and worker autonomy (Zeshan et al., 2021). Therefore, they are countries where digitalization is necessary to guarantee an appropriate socioeconomic development throughout the territory.

Q2. Have there been any improvements during the period analyzed? What is the source of these improvements?

The sequential MI is used to provide evidence on the progress of digitalization, enabling an assessment of the appropriacy of the measures adopted over these seven years in terms of improvements in productivity, and identifying the source of said improvements. Table 4 shows the results of the MI and its two components: TC, change derived from improvements in technology, that is, innovation; and EC, change resulting from advances in efficiency. Again, the regions have been grouped by geographical location to enable a comparative analysis between countries.

Table 4 shows that over the seven-year period, all regions have increased the productivity of their digital resources, although not always homogeneously, nor do we see a constant correlation with the efficiency levels shown in Table 2 (Q2). For example, in all the Spanish regions, productivity has increased on average by around 2.5%, the source of which is advances in innovation (TC) not progress in efficiency (EC). Specifically, the South and Islands should raise their outputs by more than 12%, as shown in Table 2; however, they have failed to increase EC (EC<1), devoting all their resources to the introduction of innovation to improve services (TC>1). Something

similar happens in France and Italy; again the increases in the MI are due to the introduction of advanced technologies (TC>1).

Portugal merits special mention: the Centre regions of the country have registered developments of more than 3% (MI), unlike the North, where the corresponding figure is just 1.7% (MI). That said, the Portuguese regions are the only ones to have directed efforts towards EC, although the resulting improvements are very slight (0.2% and 0.9% in the South and North, respectively). For its part, France has managed to transfer its even efficiency levels to improvements in productivity, with these being homogeneous throughout the country. On average, all French regions show increases of just above 1% (MI).

In short, the common feature in all countries is the overall disregard for EC, which in general registers no progress at all, and at best reaches 0.9%. This finding represents evidence of the need for decision-makers to promote training for citizens, facilitating their immersion in the use of these technologies, which could translate into progress in efficiency.

The scientific community has shown that the productivity gains from digitalization can be converted into improvements in supply chains. For example, Loske and Klumpp (2020) find evidence of the positive effect caused by the progress of digitalization on transport logistics over the years. Paulet and Mavoori (2020) identify the importance of new technologies for banking performance and the degree of bank customer satisfaction. Furthermore, Chen (2019) demonstrates that e-commerce performance contributes to the reduction of carbon emissions in the hotel industry. However, as confirmed by the results obtained, all these technological changes must be accompanied by appropriate training of citizens, requiring a socioeconomic revolution to take hold in all sectors. According to Kleinert (2021), this movement is lagging because society is not yet aware of how quickly these technologies are advancing.

Q3. Is there a technology gap between the analyzed countries?

Before calculating the metafrontier, it is necessary to determine whether there are significant differences between the four countries analyzed. Due to the non-normality of the variables, the Kruskal-Wallis test has been chosen for this purpose (Kruskal and Wallis, 1952). The null hypothesis to be tested is that k samples have been drawn from the same population; it can be accepted if the p-value is greater than 0.05. The alternative hypothesis is that the samples come from different populations, that is, they are significantly different.

Table 4. Results for changes in productivity: Sequential MI (2014-2020)

SPAIN				ITALY				FRANCE				PORTUGAL			
Regions	MI	TC	EC	Regions	MI	TC	EC	Regions	MI	TC	EC	Regions	MI	TC	EC
NORTH															
Galicia	1.015	1.034	0.981	Piemonte	1.022	1.032	0.99	Île de France	1.013	1.016	0.997	Norte	1.017	1.008	1.009
Asturias	1.024	1.022	1.002	Valle d'Aosta	1.067	1.067	1	Alsace	1.02	1.014	1.006				
Cantabria	1.015	1.034	0.981	Liguria	1.037	1.042	0.996	Champagne-Ardenne	1.002	1.012	0.99				
País Vasco	1.023	1.032	0.992	Lombardia	1.037	1.041	0.996	Lorraine	1.002	1.009	0.993				
Navarra	1.04	1.044	0.997	P.A. Bolzano	0.999	1.014	0.985	Picardie	1.02	1.016	1.004				
La Rioja	1.013	1.019	0.994	P.A. Trento	1.039	1.026	1.013	Basse-Normandie	1.002	1.008	0.994				
Aragón	1.008	1.022	0.986	Veneto	1.003	1.01	0.993	Haute-Normandie	1.011	1.011	1				
Cataluña	1.032	1.032	1	Friuli-Venezia Giulia	1.021	1.012	1.009	Nord-Pas-de-Calais	1.01	1.01	1				
				Emilia-Romagna	0.997	1.013	0.985	Bretagne	1.007	1.01	0.996				
Mean	1.021	1.03	0.991	Mean	1.025	1.028	0.996	Mean	1.01	1.012	0.998	Mean	1.017	1.008	1.009
CENTRE															
Madrid	1.033	1.033	1	Toscana	0.998	1.012	0.986	Centre - Val de Loire	1.002	1.011	0.991	Centro	1.018	1.018	1
Castilla y León	1.02	1.021	0.999	Umbria	1	1.011	0.99	Bourgogne	1.01	1.016	0.994	Á.M. Lisboa	1.04	1.04	1
Castilla-la Mancha	1.019	1.036	0.984	Marche	1.015	1.022	0.993	Poitou-Charentes	1.011	1.011	1	Alentejo	1.034	1.035	0.999
Extremadura	1.01	1.021	0.989	Lazio	1.03	1.03	1	Pays-de-la-Loire	1.008	1.009	0.999				
C. Valenciana	1.015	1.027	0.989	Abruzzo	1.042	1.042	1	Franche-Comté	1.015	1.021	0.994				

Table 4. (Continued)

SPAIN				ITALY				FRANCE				PORTUGAL			
Regions	MI	TC	EC	Regions	MI	TC	EC	Regions	MI	TC	EC	Regions	MI	TC	EC
								CENTRE							
				Molise	1.027	1.036	0.991	Limousin	1.028	1.028	1				
								Rhône-Alpes	1.012	1.014	0.998				
								Auvergne	1.019	1.015	1.005				
Mean	1.02	1.028	0.992	Mean	1.019	1.025	0.993	Mean	1.013	1.016	0.998	Mean	1.031	1.031	1
SOUTH AND ISLANDS															
Illes Balears	1.029	1.029	0.999	Campania	1.019	1.029	0.99	Aquitaine	1.016	1.016	1	Algarve	1.031	1.023	1.008
Andalucía	1.003	1.025	0.979	Puglia	1.036	1.033	1.002	Languedoc-Roussillon	1.008	1.014	0.995	R.A. dos Açores	1.017	1.017	1
Murcia	1	1.016	0.984	Basilicata	1.031	1.029	1.001	Midi-Pyrénées	1.017	1.012	1.005	R.A. Madeira	1.015	1.016	1
Ceuta	1.062	1.088	0.976	Calabria	1.014	1.021	0.993	Provence-Alpes-Côte d'Azur	1.011	1.017	0.994				
Melilla	1.018	1.019	0.999	Sicilia	1.014	1.019	0.994	Corse	1.035	1.035	1				
Canarias	1.012	1.036	0.977	Sardegna	1.008	1.019	0.99								
Mean	1.021	1.036	0.986	Mean	1.02	1.025	0.995	Mean	1.017	1.018	0.999	Mean	1.021	1.019	1.002
SPAIN	1.021	1.031	0.99	ITALY	1.022	1.027	0.995	FRANCE	1.013	1.015	0.998	PORTUGAL	1.025	1.022	1.002

Source: Own elaboration.

Table 5. Kruskal-Wallis test for Spain, Portugal, France and Italy

	chi-squared	p-value
Internet access at home	83.092	0.000
Broadband access	55.202	0.000
Frequency of internet access	230.612	0.000
Participating in social networks	289.424	0.000
Interaction with public authorities	408.628	0.000
Online purchases	344.982	0.000
Selling goods or services	334.416	0.000
Internet banking	318.325	0.000

Source: Own elaboration.

A Kruskal-Wallis test has been performed for each of the variables used to define the efficient frontier. As can be seen in Table 5, the p-value of all variables is less than 0.05, meaning we can reject the null hypothesis and confirm that there are statistically significant differences between the four countries. This conclusion enables the construction of a metafrontier; in other words, it is confirmed that the regions in Spain, Portugal, France and Italy operate under different technological frontiers. Table 6 shows the efficiency results calculated relative to each country (TEk) and to the metafrontier (TE) and the technology gap ratio (TGR), all of which have been calculated as the mean of the levels achieved by the regions of each country. It also includes descriptive statistics and the percentage of efficient regions.

The analysis of Table 6 requires an assessment of the differences between TEk and TE. According to TEk, the Portuguese regions need only increase their outputs by an average of 2.9% to be efficient; next comes France, then Italy, and lastly Spain. It can also be seen that the percentage of regions located at the frontier follows this same order of countries, as does the standard deviation (SD). The SD shows that the variability of the results is lower in the Portuguese regions, regardless of the setting for the calculation, TEk or TE.

Overall, these results get worse when analyzing the distance with respect to the envelope frontier (TE), except in France, where the value registered for TEk holds. TE allows comparisons between countries: it is a single frontier that envelops the regions of the four countries. In this case, France is the most efficient (3.6%), followed by Portugal (3.7%), Spain (7.5%) and Italy (17.2%). It can also be seen that the number of efficient regions drops sharply, except in France, which remains constant.

Table 6. Non-concave metafrontier (2014-2020)[1]

	Mean	SD	Min	Max	Efficient (%)
SPAIN					
TE^K	1.072	0.060	1	1.305	16.54%
TE	1.075	0.061	1	1.305	15.79%
TGR	1.003	0.013	1	1.087	
ITALY					
TE^K	1.064	0.052	1	1.213	19.73%
TE	1.172	0.107	1	1.481	13.61%
TGR	1.102	0.082	1	1.305	
FRANCE					
TE^K	1.036	0.036	1	1.165	28.57%
TE	1.036	0.036	1	1.165	28.57%
TGR	1	0	1	1	
PORTUGAL					
TE^K	1.029	0.034	1	1.120	34.69%
TE	1.037	0.034	1	1.120	22.45%
TGR	1.008	0.021	1	1.093	

Source: Own elaboration.

TGR has been calculated from the values of TEk and TE. This ratio measures the distance between the frontier of country k and the metafrontier; that is, the technology gap. As can be seen in Table 6, its value ranges from 1 to 1.102. France registers the maximum level of efficiency, where all regions have obtained a TGR equal to 1, that is, they are on the metafrontier. Using the available inputs, the French regions have produced the maximum possible output, indicating that their way of managing digitalization is the most appropriate. At the opposite extreme is Italy (Q3). If the Italian regions adopted the technology of the French regions, they could increase their output by 10.2%. Second place is held by Spain (0.3%), closely followed by Portugal (0.9%).

The implementation of digitalization at the national level requires an appropriate management of resources to minimize the possible associated problems. At the business level, Jasińska (2021) shows that in order to adapt organizations to Industry 4.0, strategies should focus on detecting business opportunities that improve performance, and subsequently implementing the necessary innovation. The digitalization process needs to take into account

[1] The results of the mean efficiency by group do not coincide with those shown in Table 2 because, in this case, given the complexity of the analysis and the objective of the research question, DEA-Bootstrap has not been applied.

aspects of strategy, leadership, culture, people, governance and technology (da Costa et al., 2019).

Conclusion

Globalization implies the connection of all countries in the world, guaranteeing the movement of people, products and services. This requires the implementation of innovative technologies that minimize distances and enable the real-time provision of solutions. It is in this scenario that digitalization is gaining ground, providing major opportunities for growth. Its implementation entails change at all levels of society, where the mere use of mobile devices is facilitating communication and collaboration in real time, cost savings and optimization of daily decision-making. These new technologies break down barriers by bringing knowledge to the people, as well as directly connecting them with services on offer, regardless of where they are from.

In order to ensure sustainable development, digitalization must be carried out evenly across all countries, avoiding delays that could slow economic growth and widen the gap between regions. This research has shown that, despite all the efforts made by the EU regarding the efficiency of digitalization, progress has not been entirely even across the regions of the member states. Moreover, we find evidence that the efforts made in recent years have been oriented towards the introduction of innovation, overlooking the need to improve the use of available services, which would improve the efficiency of the available digital resources. The study has centered on the situation of four European countries, France, Spain, Portugal and Italy. While they all have different digital technologies, it is shown that the French regions are the ones that are best managing their resources.

This analysis should be extended to all EU member states in order to assess the situation and target economic resources at those areas in greatest need. Digitalization fosters growth; hence, there is a need to facilitate its implementation to achieve a digital Europe conducive to unity and connection with the rest of the world.

References

Amankwah-Amoah, J., Khan, Z., Wood, G., & Knight, G. (2021). COVID-19 and digitalization: The great acceleration. *Journal of Business Research*, 136, 602-611.

Annosi, M. C., Brunetta, F., Capo, F., Heideveld, L. (2020). Digitalization in the agri-food industry: the relationship between technology and sustainable development. *Management Decision*, 58 (8), 1737-1757.

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis. *Management Science*, 30(9), 1078-1092. https://doi.org/10.1287/mnsc.30.9.1078.

Balsmeier, B., & Woerter, M. (2019). Is this time different? How digitalization influences job creation and destruction. *Research Policy*, 48 (8), 103765.

Battese, G. E., & Rao, D. (2002). Technology gap, efficiency, and stochastic metafrontier function. *International Journal of Business and Economics*, 1(2). 87-93.

Battese, G. E., Rao, D., & O'Donnell, C. J. (2004). A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies. *Journal of Productivity Analysis*, 21 (1), 91-103.

Boikova, T., Zeverte-Rivza, S., Rivza, P., & Rivza, B. (2021). The determinants and effects of competitiveness: The role of digitalization in the European economies. *Sustainability*, 13(21), 11689.

Bloomberg, J. (2018). Digitization, digitalization, and digital transformation: confuse them at your Peril. *Forbes*. https://www.forbes.com/sites/jasonbloomberg/2018/04/29/digitization-digitalization-and-digital-transformation-confuse-them-at-your-peril.

Bravo-Ureta, B. E., Higgins, D., & Arslan, A. (2020). Irrigation infrastructure and farm productivity in the Philippines: A stochastic Meta-Frontier analysis. *World Development*, 135, 105073.

Bresciani, S., Puertas, R., Ferraris, A., & Santoro, G. (2021). Innovation. environmental sustainability and economic development: DEA-Bootstrap and multilevel analysis to compare two regions. *Technological Forecasting and Social Change*, 172, 121040.

Caputo, A., Pizzi, S., Pellegrini, M. M., & Dabić, M. (2021). Digitalization and business models: Where are we going? A science map of the field. *Journal of Business Research*, 123, 489-501. https://doi.org/10.1016/j.jbusres.2020.09.053.

Carracedo, P., & Puertas, R. (2022). Country efficiency study based on science & technology indicators: DEA approach. *International Journal of Innovation and Technology Management*, 19, 2140005.

Caves, D. W., Christensen, L. R., & Diewert. W. E. (1982). The economic theory of index numbers and the measurement of input. output and productivity. *Econometrica*, 50(6), 1393-1414.

Cette, G., Nevoux, S., & Py, L. (2021). The impact of ICTs and digitalization on productivity and labor share: evidence from French firms. *Economics of Innovation and New Technology*.

Chang, V., & Tovar, B. (2021). Efficiency drivers for the South Pacific West coast port terminals: a two-stage non-convex metafrontier dea approach. *Operational Research*.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2(6), 429-444. https://doi.org/10.1016/0377-2217(78)90138-8.

Chen, L. F. (2019). Green certification, e-commerce, and low-carbon economy for international tourist hotels. *Environmental Science and Pollution Research*, 26, 17965–17973.

Chopra, M., Singh, S. K., Gupta, A., Aggarwal, K., Gupta, B., & Colace, F. (2022). Analysis & Prognosis of Sustainable Development Goals using Big Data-based Approach during COVID-19 Pandemic. *Sustainable Technology and Entrepreneurship*, 1, 100012.

Coll-Serrano, V., Benítez, R., & Bolos, V. J. (2018). *Data envelopment analysis with deaR*. University of Valencia, Spain.

Cone, L., Brøgger, K., Berghmans, M., Decuypere, M., Leuven, K. U., Förschler, A., Grimaldi, E., Hartong, S., Hillman, T., Ideland, M., Landri, P., van de Oudeweetering, K., Player-Ko, C., Rensfeldt, A. B., Rönnberg, L., Taglietti, D., & Vanermen, L. (2021). *Pandemic acceleration: Covid-19 and the emergency digitalization of European education*. https://doi.org/10.1177/14749041211041793.

da Costa L. S., Pereira L., & Akkari A. C. S. (2019) Organizational digital transformation: A proposed instrument for digitalization management. In *Proceedings of the 4th Brazilian Technology Symposium (BTSym'18). BTSym 2018. Smart Innovation, Systems and Technologies, 140.* Y. Iano, O. Arthur R., Saotome, V. Vieira Estrela, & H. Loschi (Eds): Springer, Cham.

de Castro-Pardo, M., Fernández, P., & Pérez-Zabaleta, A. (2022). An initial assessment of water security in Europe using a DEA approach. *Sustainable Technology and Entrepreneurship*, 1, 100002.

Di Vaio, A., & Varriale, L. (2020). Digitalization in the sea-land supply chain: experiences from Italy in rethinking the port operations within inter-organizational relationships. *Production Planning & Control*, 31, 220-232.

Ding, T., Wu, H., Jia, J., Wei, Y., & Liang, L. (2020). Regional assessment of water-energy nexus in China's industrial sector: An interactive meta-frontier DEA approach. *Journal of Cleaner Production*, 244, 118797.

Eguchi, S., Takayabu, H., & Lin, C. (2021). Sources of inefficient power generation by coal-fired thermal power plants in China: A metafrontier DEA decomposition approach. *Renewable and Sustainable Energy Reviews*, 138, 110562.

Ekinci, R. (2021) The Impact on Digitalization on Financial Sector Performance. In *The Impact of Artificial Intelligence on Governance. Economics and Finance Bozkuş*. S. Kahyaoğlu (Eds.). Singapore: Springer.

Eller, R., Alford, P., Kallmünzer, A., & Peters, M. (2020). Antecedents, consequences, and challenges of small and medium-sized enterprise digitalization. *Journal of Business Research*, 112, 119-127.

Elmassah, S., & Hassanein, E. A. (2022). Digitalization and subjective wellbeing in Europe. Digital Policy. *Regulation and Governance*, 24, 52-73.

Enciso-Santocildes, M., Echaniz-Barrondo, A., & Gómez-Urquijo, L. (2021). Social innovation and employment in the digital age: The case of the connect employment shuttles in Spain. *International Journal of Innovation Studies*, 5, 175-189. https://doi.org/10.1016/j.ijis.2021.11.001.

European Commission (2021a). *Industry 5.0: Towards a sustainable, human-centric and resilient European industry*. R&I Paper Series. Policy Brief. https://doi.org/ 10.2777/308407.

European Commission (2021b). *2030 Digital compass: the European way for the digital decade*. In COM(2021) 118 final, Brussels.

European Commission (2021c). *The EU's 2021-2027 long-term budget & NextGenerationEU: facts and figures*. https://data.europa.eu/doi/10.2761/808559.

European Commission (2021d). *Digital economy and society index* (DESI) 2021. https://digital-strategy.ec.europa.eu/en/policies/desi.

European Commission (2022). *European declaration on digital rights and principles for the digital decade*. COM(2022) 28 final URL:COM_2022_28_1_EN_ACT_part1_v1jH P0T9pDHtEAV5q9vMSutdjQ_82703.pdf.

Färe, R., Grosskopf, S., Lindgren, B., & Ross, P. (1989). Productivity developments in Swedish hospitals: a Malmquist output index approach. In *Data Envelopment Analysis, Theory, Methodology and Applications*. A. Charnes, A., W. Cooper, A. Lewin, & L. Seiford (Ed.). Kluwer Academic Publishers.

Fromhold-Eisebith, M., Marschall, P., Peters, R., & Thomes, P. (2021). Torn between digitized future and context dependent past – How implementing 'Industry 4.0' production technologies could transform the German textile industry. *Technological Forecasting and Social Change*, 166, 120620.

García-Mollá, M., Puertas, R., & Sanchis-Ibor, C. (2021). Application of data envelopment analysis to evaluate investments in the modernization of collective management irrigation systems in Valencia (Spain). *Water Resources Management*, 35, 5011–5027.

Gebre-Mariam, M., & Bygstad, B. (2019). Digitalization mechanisms of health management information systems in developing countries. *Information and Organization*, 29, 1-22.

Godwin Myovella, G., Mehmet Karacuka, M., & Justus Haucap, J. (2020). Digitalization and economic growth: A comparative analysis of Sub-Saharan Africa and OECD economies. *Telecommunications Policy*, 44, 101856.

Grigorescu, A., Pelinescu, E., Ion, A. E., & Dutcas, M. F. (2021). Human capital in digital economy: An empirical analysis of central and eastern European countries from the European Union. *Sustainability*, 13, 2020.

Guaita Martínez, J. M., Carracedo, P., Gorgues Comas, D., & Siemens, C. H., (2022). An analysis of the Blockchain and COVID-19 research landscape using a bibliometric study. *Sustainable Technology and Entrepreneurship*, 1 (1), 100006. https://doi.org/10.1016/j.stae.2022.100006.

Han, L., Hou, H., Bi, Z. M., Yang, J., & Zheng, X. (2021). Functional requirements and supply chain digitalization in industry 4.0. *Information Systems Frontiers*.

Hayami, Y. (1969). Sources of agricultural productivity gap among selected countries. *American Journal of Agricultural Economics*, 51, 564-575.

Hayami, Y., & Ruttan, V. W. (1970). Agricultural productivity differences among countries. *American Economic Review*, 60, 895-911.

Hayami, Y., & Ruttan, V. W. (1971). Agricultural development: An international perspective. Baltimore: John Hopkins University Press.

Hope, D. L., & Campbell, C. (2021). Sustainability via PebblePad digitization of pharmacy practice resources. *Currents in Pharmacy Teaching and Learning*, 14, 173-181.

Inel, M. N. (2019). An empirical study on measurement of efficiency of digital transformation by using data envelopment analysis. *Management Science Letters*, 9, 549-556.

Jasińska, K. (2021). The digital chasm between an idea and its implementation in Industry 4.0—The case study of a Polish service company. *Sustainability*, 13, 8834.

Katz, R., Jung, J., & Callorda, F. (2020). Can digitization mitigate the economic damage of a pandemic? Evidence from SARS. *Telecommunications Policy*, 44, 102044.

Kleinert, J. (2021). Digital transformation. *Empirica* 48, 1–3.

Komarova, A. A., Karpova, E. G., & Zavelskaya, I. M. (2022) Educational Problems in Russian Universities in the Context of Society Digitalization. In *Proceedings of the International Scientific Conference Smart nations: Global trends in the digital economy. Lecture Notes in Networks and Systems*. S. I. Ashmarina, V. V. Mantulenko, & M. Vochozka (Ed.). Springer. Cham. https://doi.org/10.1007/978-3-030-94870-2_43.

Kruskal, W. H., & Wallis, W. A. (1952). Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association*, 47, 583-621.

Kumar, R., Gupta, P., Singh, S., & Jain, D. (2021) Human Empowerment by Industry 5.0 in Digital Era: Analysis of Enablers. In *Advances in Industrial and Production Engineering. Lecture Notes in Mechanical Engineering*. R. K. Phanden, K. Mathiyazhagan, R. Kumar, & J. Paulo Davim (Ed.). Singapore: Springer.

Lange, S., Pohl, J., & Santarius, T. (2020). Digitalization and energy consumption. Does ICT reduce energy demand? *Ecological Economics*, 176, 106760.

Lapão, L. V. (2019) The Future of Healthcare: The Impact of Digitalization on Healthcare Services Performance. In *The Internet and Health in Brazi.* A. Pereira Neto, & M. Flynn (Ed). Springer. Cham.

Lioutas, E. D., Charatsari, C., & De Rosa, M. (2021). Digitalization of agriculture: A way to solve the food problem or a trolley dilemma? *Technology in Society*, 67, 101744.

Llopis-Albert, C., Rubio, F., & Valero, F. (2021). Impact of digital transformation on the automotive industry. *Technological Forecasting and Social Change*, 162, 120343. https://doi.org/10.1016/j.techfore.2020.120343.

Loske, D., & Klumpp, M. (2022). Verifying the effects of digitalisation in retail logistics: an efficiency-centred approach. *International Journal of Logistics Research and Applications*, 25, 203-227.

Matt, D. T., Pedrini, G., Bonfant, A., & Orzes, G. (2022). Industrial digitalization. A systematic literature review and research agenda. *European Management Journal*. In Press.

Mugge, P., Abbu, H., Michaelis, T. L., Kwiatkowski, A., & Gudergan, G. (2020). Patterns of digitization. *Research-Technology Management*, 63, 27-35.

Nell, P. C., Foss, N. J., Klein, P. G., & Schmitt, J. (2021). Avoiding digitalization traps: Tools for top managers. *Business Horizons*, 64, 163-169.

Noussan, M., & Tagliapietra, S. (2020). The effect of digitalization in the energy consumption of passenger transport: An analysis of future scenarios for Europe. *Journal of Cleaner Production*, 258, 120926.

O'Donell, C. J., Rao, D. S. P., & Battese, G. E. (2008). Metafrontier frameworks for the study of firm-level efficiencies and technologies ratios. *Empirical Economics*, 34, 231-255.

Papadopoulos, T., Singh, S. P., Spanaki, K., Gunasekaran, A., & Dubey, R. (2022). Towards the next generation of manufacturing: implications of big data and

digitalization in the context of industry 4.0. *Production Planning & Control*, 33, 101-104.

Paulet, E., & Mavoori, H. (2020). Conventional banks and Fintechs: how digitization has transformed both models. *Journal of Business Strategy*, 41, 19-29. https://doi.org/10.1108/JBS-06-2019-0131.

Polycronidou, P., Zoumpoulidis, V., Valsamidis, S. (2021). Labour digitalization in Europe. *Intelektinė Ekonomika* [*Intellectual Economy*] 2, 6-21.

Puertas, R. M., Martín, J. M., Guaita Martínez, J. M., & Serdeira Azevedo, P. (2022). Analysis of the role of innovation and efficiency in coastal destinations affected by tourism seasonality. *Journal of Innovation & Knowledge*, 7, 100163.

Puertas, R., & Marti, L. (2021). Eco-innovation and determinants of GHG emissions in OECD countries. *Journal of Cleaner Production*, 319, 128739.

Puertas, R., Marti, L., & Guaita-Martinez, J. M. (2020). Innovation, lifestyle, policy and socioeconomic factors: An analysis of European quality of life. *Technological Forecasting and Social Change*, 160, 120209.

Raimo, N., De Turi, I., Ricciardelli, A., & Vitolla, F. (2021). Digitalization in the cultural industry: evidence from Italian museums. *International Journal of Entrepreneurial Behavior & Research*.

Ren, S., Hao, Y., Xu, L., Wu, H., & Ba, N., (2021). Digitalization and energy: How does internet development affect China's energy consumption? *Energy Economics*, 98, 105220. https://doi.org/10.1016/j.eneco.2021.105220.

Rodrigues, M., & Franco, M. (2021). Digital entrepreneurship in local government: Case study in Municipality of Fundão, Portugal. *Sustainable Cities and Society*, 73, 103115. https://doi.org/10.1016/j.scs.2021.103115.

Sala-Garrido, R., Molinos-Senante, M., & Hernández-Sancho, F. (2011). Comparing the efficiency of wastewater treatment technologies through a DEA metafrontier model. *Chemical Engineering Journal*, 173, 766-772.

Schallmo, D. R. A., & Williams, C. A. (2018). History of digital transformation. In: *Digital Transformation Now!* Springer Briefs in Business. Springer. Cham. https://doi.org/10.1007/978-3-319-72844-5_2.

Shen, Z., Bai, K., Hong, T., & Balezentis, T. (2021). Evaluation of carbon shadow price within a non-parametric meta-frontier framework: The case of OECD. ASEAN and BRICS. *Applied Energy*, 299, 117275.

Simar, L., & Wilson, P. W. (2007). Estimation and inference in two stage. semi-parametric models of production processes. *Journal of Econometrics* 136(1), 31-64. https://doi.org/10.1016/j.jeconom.2005.07.009.

Simar, L., & Zelenyuk, V. (2011). Stochastic FDH/DEA estimators for frontier analysis. *Journal of Productivity Analysis*, 36, 1–20.

Tiedemann, T., Francksen, T., & Latacz-Lohmann, U. (2011). Assessing the performance of German Bundesliga football players: a non-parametric metafrontier approach. *Central European Journal of Operations Research*, 19, 571–587.

Tulkens, H., & Eeckaut, P. V. (1995). Non-parametric efficiency, progress and regress measures for panel data: methodological aspects. *European Journal of Operational Research*, 80, 474-499.

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, 122, 889-901.

Vrana, J., & Singh, R. (2021). Digitization, digitalization, and digital transformation. *Handbook of Nondestructive Evaluation 4.0*, 1-17.

Wang, B., Liu, Y., Qian, J., & Parker, S. K. (2021). Achieving effective remote working during the COVID-19 pandemic: A work design perspective. *Applied Psychology*, 70, 16-59.

Warner, K. S. R., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning*, 52, 326-349.

Xiang, Z. (2018). From digitization to the age of acceleration: On information technology and tourism. *Tourism Management Perspectives*, 25, 147-150.

Yalçin, E. C. (2021). Efficiency Measurement of Digitalization on EU Countries: A Study Based on Data Envelopment Analysis. *International Journal of Management. Knowledge and Learning*, 10, 323-333.

Yu, J., Zhou, K., & Yang, S. (2019). Regional heterogeneity of China's energy efficiency in "new normal": A meta-frontier Super-SBM analysis. *Energy Policy*, 134, 110941.

Yuan, S., Musibau, H. O., Genç, S. Y., Shaheen, R., Ameen, A., & Tan, Z. (2021). Digitalization of economy is the key factor behind fourth industrial revolution: How G7 countries are overcoming with the financing issues? *Technological Forecasting and Social Change*, 165, 120533.

Zeshan, M., Qureshi, T. M., & Saleem, I. (2021). Impact of digitalization on employee's autonomy: evidence from French firms. *VINE Journal of Information and Knowledge Management Systems.*

Zhao, Y., Xia, S., Zhang, J., Hu, Y., & Wu, M. (2021). Effect of the digital transformation of power system on renewable energy utilization in China. *IEEE Access*, 9, 96201-96209.

Chapter 2

Digitalization in EU Companies: Challenges and Evolution

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Abstract

Companies in the European Union are increasingly introducing advanced technological tools to achieve digital transformation. This situation requires introducing and implementing the Internet of Things and Big Data, among others.

Digital transformation in companies is key to success in Industry 4.0, and companies that do not introduce advanced digitalization techniques are doomed to failure in the future. This study assesses how far this transformation is progressing in the EU compared to other major players such as the UK and the US. The data was obtained from an annual survey produced by the European Investment Bank and conducted on 13500 companies year on year in the EU, the UK and the US. The research focused on the level of digitalization in four main production sectors: Manufacturing, Infrastructure, Construction, and Services, and included data from 2017 to 2020.

The data showed that many EU companies are less digital than those in the US and on par with those in the UK. Specifically, the U.S. has advanced digital technologies implemented in 73% of companies,

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compared to 63% in Europe and 59% in the UK. The biggest difference in digital transformation was especially evident in small businesses, with a 13% difference (EU: 47.7%, US: 60.8%). This gap was also high for micro enterprises (EU: 39.7%, US: 48.8%) and SMEs (EU: 51.6%, US: 59.1%). In contrast, the difference was non-existent for medium-sized companies and 4.1% (EU: 75.4%, USA: 79.7%) for large companies. Looking at sectors, the biggest difference was found in the Construction sector, where EU companies were 37% behind in digital transformation compared to the US (EU: 40%, US: 77%). The most evenly matched sector was Manufacturing, with both at around 68% digitalization and a difference of 2%.

Europe is at a crossroads. The importance of digitalization today makes it essential for EU companies to adapt to the latest techniques, e.g., introducing drones in the construction sector, IoT and Big Data in manufacturing companies. The lack of digital transformation is a major challenge in Europe, where it lags behind the US. Critical measures should be introduced to accelerate the deployment of advanced technologies in the EU.

Keywords: European Union, digitalization, Industry 4.0, global digitalization

Introduction

Digitalization has been identified as one of the major trends changing business and society (Parviainen et al., 2017). Digitalization causes changes in companies due to the adoption of digital technologies. In fact, digitalization shapes the way companies are managed in current times. Although different frameworks try to define what exactly digitalization means, it is generally considered as a change in individuals, companies and society in the short and long term related to Information Technologies. Here we will refer to digitalization as digital transformation, including three levels: From the basic analog-to-digital conversion or digitization to the creation of new business models or digital transformation, including the intermediate step, digitalization, or the modification of business processes (Verhoef et al., 2021).

On the one hand, digitization is "the process of changing data into a digital form that can be easily read and processed by a computer" (Oxford English Dictionary, n.d.), i.e., transforming analog paper and pencil information into digital data. On the other hand, both digitalization and digital transformation refer to changes in society and businesses at all levels due to digital technologies (Agarwal, 2010; Majchrzak, 2016).

Let's introduce examples for the three levels: Digitization, Digitalization, and Digital Transformation. An example of digitization could be moving from manually counting the number of parts in a warehouse and recording it on paper, to having a digital record of the parts, thus allowing the entire company to see the status of the warehouse. The next level, digitalization, could be exemplified by the introduction of automatic triggers that alert managers that a product needs to be replenished before it runs out. It could also be the automated ordering of the product without any human intervention. Finally, an example of Digital Transformation is Industry 4.0 or smart manufacturing which, through the introduction of the Internet of Things (IoT), cloud computing, Artificial Intelligence (AI) and Big Data, among others, moves the monitoring of the manufacturing process to AI-based decisions that are directly implemented.

Following Parvianen et al., (2017), we could differentiate four different levels of digital transformation, depending on who it affects:

- Social level: Modify how society is structured, with collaborative ecosystems between academia, the private sector, civil society and public organizations (Pappas et al., 2018).
- Enterprise level: Introduction of changes in the Value Chain through IT.
- Organizational level: Offering new services and traditional services in a novel way.
- Process level: Introduce digital tools and reduce manual steps, improving processes.

Although the world is global, companies in the European Union (EU), China, United States of America (USA), etc. are very different in terms of size, culture, source materials, political structures, etc. (Ghemawat, 2001). Moreover, the levels of digitalization are different among these actors. In this paper, we aim to show the state of digital transformation in the EU as a whole and in individual countries.

The rest of the article is structured as follows. Section 2 reviews the literature on Industry 4.0, Big Data and the Internet of Things. Section 3 explains the data and methods used. Section 4 presents the research results obtained by applying the analysis. Section 5 summarizes the conclusions of the study and its limitations.

Theoretical Framework

Digitization can be defined as the conversion of analog information in any form, such as sound, text, images, and physical attributes, to a digital format so that the information can be processed, transmitted, and stored through networks, electronic devices, and digital circuits (Ng & Wakenshaw, 2017). Digitization blurs the lines between management and technology, facilitating new business models built on the concepts, methods and tools of the digital environment. Moreover, digitalization is the use of digital technologies to change business models, creating new benefits and opportunities to generate value, moving from a non-digital to a digital business (Gartner Glossary, n.d.b) Sestino et al., (2020) investigate the role of Big Data and the Internet of Things (IoT) in terms of managing the digital transformation of companies. Thus, Industry 4.0 and its main components, Big Data and the Internet of Things, play a crucial role in creating disruption at a Schumpeterian level leading to the process of turning previously immovable and static information into a dynamic and transportable resource.

Industry 4.0

The Fourth Industrial Revolution or Industry 4.0 is a paradigm shift towards a more advanced digital transformation in manufacturing. This term was coined in Germany and adopted by the German government, specifically by two ministries: The Ministry of Education and Research and the Ministry of Economics and Energy (Platform-i40, n.d.). The earlier stages of the industrial revolution began with the first industrial revolution, at the end of the 18th century, with machines such as the mechanical loom, which enabled the mass production of goods. The second industrial revolution began in the 20th century and consisted of the mass production of goods with electric power based on the division of labor. Subsequently, the third industrial revolution or digital revolution (1970s) introduced electronics and IT to achieve greater automation of manufacturing processes. With the advent of the third revolution, manual labor was reduced, but also intellectual labor was adopted by machines. Finally, currently, the fourth industrial revolution is taking place, which consists of the intertwining of the physical world with the virtual world (Colombo et al., 2014), with IoT as the most prominent exponent and Big Data.

As discussed above, digitalization is increasing rapidly and companies must find new ways to innovate to take advantage of the business. Thus, new business and optimization opportunities can capitalize on this advantage through digital transformation, the use of new technologies such as cloud, mobile, big data and social networks along with increased intelligence and automation (Salminen et al., 2017). The capacity and availability of data has grown exponentially, coining the term Big Data (Sagiroglu 2013). Supermarkets were systematically studying user behavior as early as the 1990s, and there was considered to be a wealth of information, which was expanding with the Internet (although Big Data as such did not exist and the way to manage data was the Data Warehouse) (de Fatima Rodrigues et al., 1998). Data warehousing allowed business leaders to view processes in easy-to-use dashboards and capture information about their customers. However, data warehousing was slow and extremely manual. Big data refers to both the explosion of data and the tools to analyze the vast amounts of data. The main characteristics of Big Data are: Velocity, Volume and Variety. A huge amount of data (volume), which is generated at high speed (velocity) and is heterogeneous (variety), needs new tools for visualization, aggregation, normalization and storage that allow companies to take advantage of humongous amounts of data collected from their own companies, competitors, customers, etc.

According to Sestino et al., (2020), Big data together with the Internet of Things (IoT) have been a point of disruption providing added value not only for companies but also for individuals. Indeed, all these everyday objects are equipped with wi-fi networks, sensors and computing enhancements. Therefore, there are billions of physical devices possessing computing facilities that allow to collect a lot of information in real time (Guo et al., 2013). Thus, the combination of Big data and IoT can help not only companies but also public institutions to increase their competitiveness by transforming their services and products into digital opportunities. These voluminous amounts of data make it possible to offer advanced healthcare systems, industrial automation, smart city devices, among others. For example, this combination has given rise to Intelligent Marketing in Smart Cities (Chen and Ji, 2016) through crowdsourced data.

Gartner defines IoT as the "network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment" (Gartner, n.d.). Even though the term Internet of Things is becoming more widely used, there is no consensus or common understanding of what IoT actually encompasses (Wortman and

Flüchter, 2015). As Weber and Weber (2015) state, the IoT is gradually developing and comprises a global Internet-based information architecture that facilitates the exchange of goods and services. The possibilities of IoT are broad, including success stories in factories (e.g., waste efficiency as in Kabugo et al., 2020; battery module assembly factories as in Kahveci et al., 2022), autonomous vehicles (e.g., Khayyam et al., 2020), and a wide range of applications in different areas such as smart grids, robotics, smart cities, smart homes, health monitoring, traffic, logistics, retail, etc. (Colakovic and Hadzialic, 2018), etc. Asghari et al., (2019) propose a taxonomy of IoT applications divided into 6 main groups: healthcare, environment, smart city, commercial, industrial and general aspects. At the same time, commercial applications can be subdivided into shopping and retail systems, while industrial applications are divided into smart grid and scheduling systems.

Specifically, in the IoT and smart grid domain, in Reka and Dragicevic (2018), three segments, with use cases, are detected: First, the Energy Delivery and Peak Demand segment, with the following typical cases: Smart Meter Reading, Control System for Advanced Transmission and Distribution, and Online Monitoring of Power Generators. Secondly, the residential, commercial and industrial segment, with cases such as Home Energy Management, Electric Vehicle Charging and Demand Response Modeling. Finally, a third segment is detected, Utilities / Consumers, with Smart meter/ automated meter reading (electric water, gas, heat), Asset management and .

Robotics has evolved to accommodate to Industry 4.0. Key features include the Internet of Things, so that robots can be connected like any other part of the manufacturing process, and Artificial Intelligence, which allows robots to collaborate on tasks. This takes robots to a new level, where they not only handle tasks designed for isolated automated work, but also autonomous tasks.

The application of robotics in Industry 4.0 has enormous benefits. They offer precision, repeatability, reliability, productivity and intelligence. Thus, they can complete many automated tasks, including some that would not be possible for humans (e.g., performing work in extreme conditions of temperature, weather, etc.).

A seminal research (Grieco et al., 2014) focused on fields of interaction between IoT and robotics that have been validated over time: Healthcare applications, e.g., remote surgery (Shabana, Velmathi, 2018) or IoT robotics support to rehabilitation (Meng et al., 2018); industrial plants, including nuclear power plant management (Iqbal et al., 2012), renewable energy management - assisting both the production and service side of the value

chain, with inspection and maintenance of utilities (Iqbal, 2019); military applications (Sapaty, 2015); and rescue management systems; in the mining industry, several applications help reduce costs and risks to human lives (Molaei et al., 2020, Wanasinghe et al., 2020).

In general, the benefits of IoT are manifold, and depend on the characteristics of the activity in which the IoT is applied. For the use of IoT in some business activities, the technology must be enhanced to achieve easy deployment, self-maintenance and security in several crucial aspects such as authentication, data privacy, robustness against attacks, etc. (Fernández-Caramés and Fraga-Lamas, 2018). The advantages of IoT in less demanding technological infrastructure contexts are easily achievable, and the application of IoT in these environments is spreading rapidly.

In smart cities, for example, IoT encompasses aspects such as traffic reduction, improved security, infrastructure planning, smart street lighting, telepresence, smart parking systems, geographic information, etc. The implementation of IoT in cities requires the integration of a wide variety of technologies. For example, a simple project to collect environmental data such as CO2 level, humidity, temperature, vibration and noise (Talari et al., 2017) through sensors requires the interconnection of multiple devices and the integration of different technologies (Zanella et al., 2014).

In the case of smart home applications, IoT can help in energy conservation, healthcare (especially for the elderly and people with disabilities), comfort, safety, and security (Alaan et al., 2017).

In more demanding activities, such as remote control IoT, devices must connect efficiently with very low latency (minimum delay in messages between sender and receiver) and this is one of the main objectives of 5G connections. Moreover, since IoT will have an impact in different areas, a regulatory framework will help to ensure the security of the structure as well as the privacy of its potential users (Weber & Weber, 2015). But the implementation of IoT is a combination of technologies and processes, and more complex applications, such as collision avoidance systems, require a full development of IoT enabling technologies. Open system interconnection layers need to be standardized and the services that provide them need to be developed. According to Colakovic and Hadžialic (2018), there are still challenges to overcome in full IoT deployment, such as standardization, architecture, interoperability, reliability, data processing and storage, self-configuration, identification, power consumption, and security.

But the different applications and benefits of IoT will be explored by enterprises when the technology infrastructure supporting it reaches a

complete state. In this sense, the integration of other technologies with IoT, such as Blockchain Technology and Artificial Intelligence, may provide some of the characteristics of the next radical innovations in business models and personal tools. Krotov (2017) describes IoT as an emerging phenomenon that offers new business opportunities to empower entrepreneurs and existing companies. One of the clearest applications of IoT in business activities is supply chain management. IoT can optimize supply networks by changing the configuration of the physical supply chain system. IoT can control costs, vehicle routes and even the quality of perishable goods.

At the same time, the wide deployment of IoT generates massive data that can be exploited by data mining. Data mining functionalities include classification, clustering, association analysis, time series analysis, and outlier analysis (Chen et al., 2015).

Extracting hidden information from data collected through IoT has high business value (Chen et al., 2015). The extensive data generated by IoT can also help to increase the responsiveness and transparency of authorities in public management and can favour the control and participation of citizens in the proposed resolution of public problems.

But some applications of IoT are controversial. For example, security has been greatly enhanced by surveillance devices, such as cameras connected to smart processing. With these systems, the privacy of citizens depends on the enforcement of data protection laws and the proper functioning of institutions. This security can be extended to any type of belonging through IoT that allows the location and use of any product. Maintenance of complex products such as vehicles and household appliances can be tracked. Data on how products are used, when and how they malfunction, and how they are handled without the vendor's supervision are important for product improvement and customer satisfaction. In addition, the product can be protected against thieves and security can be improved. However, the buyer can lose full control of the product. The seller can oblige, always under previous contractual agreements, strict maintenance at the seller's premises after the sale and block the operation of the product if tampering is detected. Product usage data can be a source of conflict between buyer and seller if there is no clear agreement on privacy and data protection.

Materials

This paper will present the current state of digital transformation in Europe compared to that in the United States. The information introduced here is available online as an open-access repository published by the European Investment Bank (EIB Investment Survey, n.d.). It comprises aggregated annual survey data including qualitative and quantitative information. The EIB Investment Survey is conducted every year and its main objective is to provide the EIB with robust information on the investment situation in the 27 EU member countries, the UK and the US (Ipsos MORI, 2020). It has been conducted every year since 2016, with some general questions repeated annually and specific questions that are different each year. The information from U.S. companies allows us to compare with that of the EU.

Although the data focuses mainly on the investment activities, financing needs and financial difficulties of companies, it also provides information on other areas, such as digital transformation in these companies.

Data include surveys of 13,500 companies. Data are represented as the aggregation of companies in each region.

The specific fields considered are:

- EU Member countries, EU as a whole, United Kingdom, United States
- Company size
- Answer to a specific question about digitalization.
- Sector of the company

Companies were selected from NACE categories C to J with at least five employees. Respondents were senior managers, and could be the owner, the CEO, the CFO or a Finance Manager.

The survey consisted of more than 40 questions. The question of interest here was:

> "Can you tell me for each of the following digital technologies whether you have heard of them, whether you have not heard of them, whether you have implemented them in parts of your business, or whether your entire business is organized around them?" (European Investment Bank, 2021).

The following sectors were studied: Manufacturing, Construction, Services, and Infrastructure.

The possible answers on advanced digital technologies depended on the sector. IoT deployment was a possible answer for all sectors. 3D printing was a possibility for all sectors except services. Big data was a possible answer for all sectors except construction. Specifically, in manufacturing, it was asked about possible automation through advanced robotics. In construction, the implementation of drones was asked about, as well as virtual or augmented reality. Companies in the service sector were asked about virtual reality and platforms (systems that connect business-to-business or business-to-consumer). Finally, infrastructure also included platforms.

Table 1. Advanced digital technologies questioned in each sector

Sector	*Technologies*
Manufacturing	3D printing (additive printing) Big data / AI Robotics IoT
Construction	3D Printing Drones IoT Big data / AI
Services	VR / AR Platforms IoT Big data / AI
Infrastructure	3D Printing Platforms IoT Big data / AI

Source: Own elaboration.

With these data, companies could be segmented as "digital, single technology" if they implemented at least one technology. If they implemented more than one, they were classified as "digital, multiple technologies." They could also be "non-digital" (no advanced digital implementation).

Current Situation in the EU

The lack of comprehensive statistics prevents an analysis of the data by company, which would have shed light on the differences between individual companies.

The 2020 survey wave (which includes 2019 data) showed that many EU companies are less digital than those in the U.S. and on par with the UK. Specifically, the U.S. has advanced digital technologies implemented in 73% of companies, compared to 63% in Europe and 59% in the UK.

Comparing companies in the EU with those in the US, the biggest difference in digital transformation was particularly evident in small companies, with a 13% difference (EU: 47.7%, US: 60.8%). This gap was also high for micro enterprises, with a 9.1% difference (EU: 39.7%, US: 48.8%) and for SMEs, with a 7.5% difference (EU: 51.6%, US: 59.1%). On the other hand, the difference was non-existent in medium-sized companies, and in large companies it was 4.1% (EU: 75.4%, USA: 79.7%). These metrics and differences can be seen in Table 2.

Table 2. Digital transformation in the EU, USA, UK separated per company size

Company digitalization: Company Size			
	EU	*USA*	*UK*
Micro	40%	49%	42%
Small	48%	61%	49%
SME	52%	59%	54%
Medium	61%	60%	64%
Large	75%	80%	63%
All	63%	74%	59%

Source: Own elaboration.

Table 3. Digital transformation in the EU, USA, UK, per sector

Company digitalization: Sector			
	EU	*USA*	*UK*
Manufacturing	67%	70%	60%
Construction	40%	77%	69%
Infrastructure	55%	79%	67%
Services	60%	72%	59%
All	63%	74%	59%

Looking at sectors, the biggest difference was found in the Construction sector, where EU companies were 37% behind in digital transformation compared to the U.S. (EU: 40%, U.S.: 77%). The sector that was most on par

was Manufacturing, with both at around 68% digitalization and a difference of 2%. The Infrastructure sector showed a difference of 11% (EU: 67.7%, US: 78.7%). In this sector, the UK accounted for an even smaller digital transformation of 23.5% compared to the US (UK: 55.2%). Finally, services show a 12% difference between the EU and the US (EU: 60%, US: 72%). The level of digitalization by sector size is available in Table 3.

Table 4. Digital transformation in the EU member states, per sector

Company digitalization: Countries and Sectors					
	ISO Code	Manufacturing	Construction	Infrastructure	Services
EU Country					
Austria	AT	73%	34%	73%	60%
Belgium	BE	75%	44%	76%	62%
Bulgaria	BG	56%	31%	52%	63%
Croatia	HR	66%	56%	59%	65%
Cyprus	CY	35%	54%	0%	55%
Czechia	CZ	79%	55%	80%	70%
Denmark	DK	82%	49%	78%	74%
Estonia	EE	79%	50%	59%	59%
Finland	FI	84%	58%	75%	75%
France	FR	64%	27%	58%	40%
Germany	DE	66%	35%	60%	63%
Greece	EL	48%	45%	63%	54%
Hungary	HU	69%	38%	60%	66%
Ireland	IE	58%	51%	39%	41%
Italy	IT	62%	37%	82%	66%
Latvia	LV	61%	61%	66%	58%
Lithuania	LT	52%	27%	68%	69%
Luxembourg	LU	58%	50%	77%	63%
Malta	MT	46%	0%	69%	54%
Poland	PL	64%	27%	39%	48%
Portugal	PT	67%	44%	84%	61%
Romania	RO	48%	24%	71%	60%
Slovakia	SK	69%	62%	71%	68%
Spain	ES	76%	58%	82%	68%
Sweden	SE	82%	50%	73%	64%
Switzerland	SI	80%	34%	60%	46%
The Netherlands	NL	73%	71%	85%	73%
EU countries	EU	67%	40%	68%	60%
Country					
UK	UK	60%	69%	55%	59%
USA	USA	70%	77%	79%	72%

Table 5. Digital transformation in EU member states, by company size

Company digitalization: Countries and Company Size						
	ISO Code	Micro	Small	SME	Medium	Large
EU Country						
Austria	AT	49%	52%	54%	59%	77%
Belgium	BE	39%	51%	54%	65%	86%
Bulgaria	BG	37%	44%	46%	51%	67%
Croatia	HR	47%	60%	60%	64%	65%
Cyprus	CY	38%	48%	50%	56%	0%
Czechia	CZ	56%	62%	66%	72%	84%
Denmark	DK	46%	55%	60%	71%	91%
Estonia	EE	43%	49%	57%	67%	0%
Finland	FI	43%	52%	62%	80%	92%
France	FR	28%	33%	37%	46%	64%
Germany	DE	33%	45%	47%	53%	74%
Greece	EL	44%	48%	50%	55%	63%
Hungary	HU	36%	33%	40%	48%	84%
Ireland	IE	36%	41%	46%	56%	0%
Italy	IT	39%	48%	57%	78%	82%
Latvia	LV	42%	47%	51%	56%	83%
Lithuania	LT	44%	45%	51%	58%	76%
Luxembourg	LU	45%	53%	55%	59%	84%
Malta	MT	22%	50%	50%	60%	0%
Poland	PL	42%	36%	42%	45%	57%
Portugal	PT	46%	56%	58%	65%	85%
Romania	RO	42%	49%	46%	46%	64%
Slovakia	SK	63%	58%	63%	68%	73%
Spain	ES	48%	65%	64%	72%	85%
Sweden	SE	41%	55%	60%	72%	83%
Switzerland	SI	33%	58%	58%	66%	73%
The Netherlands	NL	69%	61%	68%	73%	87%
EU countries	EU	40%	48%	52%	61%	75%
Country						
UK	UK	42%	49%	54%	64%	63%
USA	USA	49%	61%	59%	60%	80%

Discussion

The data shows greater digital transformation in the U.S., both across sectors and firm size. In terms of company size, the UK is broadly on par with the EU. However, large firms, which have the highest level of digitalization in both the US and the EU, are less digitally transformed in the UK. and small-sized companies in the EU and the UK are important, as they account for much of

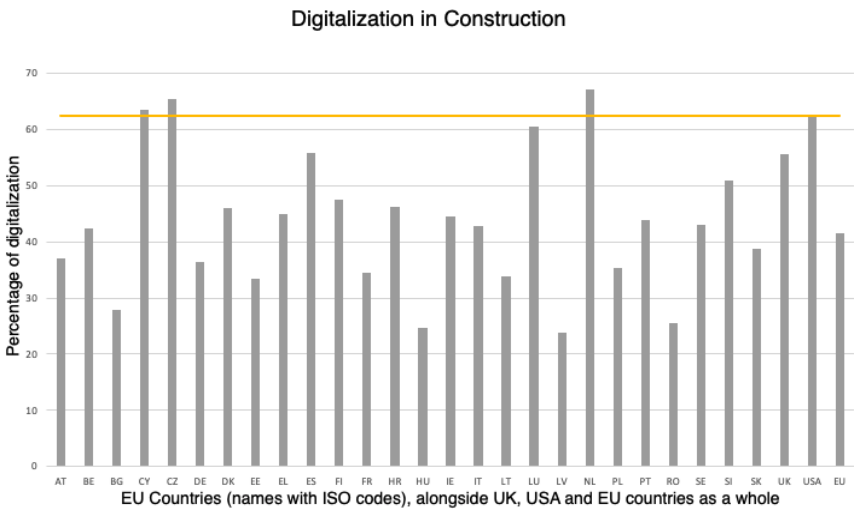
the turnover in these regions. The top 10 largest companies by consolidated revenue in 2021 include 5 US companies (Walmart, Amazon, Apple, CVS Health and United Health), 3 Chinese companies (State Grid, China National Petroleum, Sinopec Group), 1 Japanese company (Toyota) and only 1 EU company (Germany: Volkswagen) (Fortune Global 500 2021, n.d.). The top 100 includes only 5 EU companies, while there are 23 US and 2 UK companies. This indirectly shows that the size of companies is smaller in the EU, where the majority are micro, small and SME companies. They represent 99% of all EU companies and account for more than half of European GDP. Almost 100 million people work in SMEs. These small and medium-sized enterprises (SMEs) thus represent the backbone of the EU economy. Moreover, they are essential to the EU's twin transition to a sustainable and digital economy.

We can see that the larger the company, the greater the digitalization in the EU, the UK and the US. As stated by the Secretary General of the Organisation for Economic Co-operation and Development (OECD), Angel Gurriá, "there will be no sustainable digital transformation without our SMEs" (Kergroach, 2020). As recognized in the 2019 Global Digital SME Initiative (ibidem), SMEs lag behind large enterprises in many respects: They are less connected to high-speed broadband, have less access to the data-driven economy, and struggle to move their infrastructures to cloud computing for ubiquitous access, flexible storage, and dynamic processing power.

As shown in Table 5, there is a digital divide between company sizes: The smaller the company, the lower the advanced digitalization. This makes smaller companies more vulnerable. From the SME initiative, we have corroborating information that in all OECD countries the high-speed digital divide has increased in the period 2011-2018. In fact, in Ireland, the connectivity gap has increased over the period. In other countries such as Belgium, Germany and the UK, the digital connectivity gap has become three times larger in SMEs compared to large enterprises. Moreover, and this is of utmost interest here, the smaller the companies, the longer it takes for them to digitally transform. As an example, in 2018 most small businesses were not likely to use cloud computing services, while large businesses were more likely to buy such services.

Separate digital transformation by sector shows that differences are significant between regions within sectors. For example, the Construction sector is highly digitalized in the US; the UK is 8% less digitalized, and the EU is 29% behind the UK. As we can see, Construction digitalization in the

EU is very low, at only 40%, and lagging behind, both compared to the US and the UK.



Source: Own elaboration.

Figure 1. 2019 construction digitalization rate in the 27 EU countries, the United Kingdom, the United States and the EU average. The orange horizontal line marks the digitalization rate in the United States. Countries are shortened by their ISO codes.

Traditionally, the construction sector has been one of the least digitalized industries in the world, but today companies in Europe are under pressure to embrace technology. Lately, construction consumers are demanding more communication during the construction process and ownership over project data.

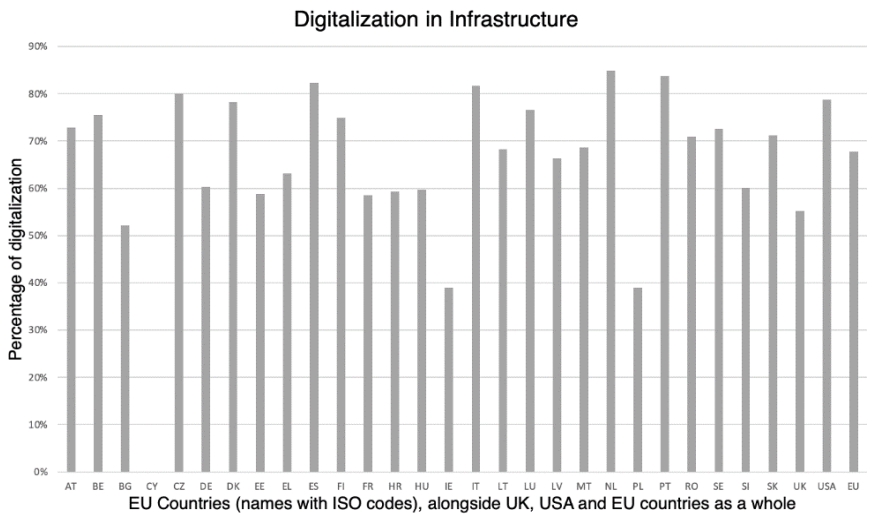
There is one digital technology in the construction industry that is widely used: Building Information Modeling (BIM). It was initially based on the BS1192: 2007 standard and evolved into ISO 19650. BIM is interpreted and applied differently in different regions of the world-see, for example, Lea et al., 2015. Building information modeling with BIM can be considered the successor to Computer-Aided Design, and includes pre-planning, design, construction and integrated project delivery of the building (Volk et al., 2014). The importance of BIM in the industry lies in the fact that it is the centerpiece in the digital transformation in construction as it becomes the software that integrates building design, modeling and planning, but also provides all

stakeholders with real-time project management; and then a lifecycle view of the asset that enables the integration of other digital technologies.

According to Jung et al., (2015), there are differences in the level of implementation, with 55.9% depth of implementation and a ratio of 75% across the European continent, compared to 73% and 82%, respectively, in North America (Jung, 2015). Although this comparison was made between continents (Europe included countries outside the EU, and North America included Canada), this confirms that the level of digitalization respective to BIM is higher in the United States than in the EU.

It should be noted that the U.S. was the pioneer in adopting and developing BIM in the construction industry in the 1970s. BIM is not yet mandatory across all states, but it is expected to grow significantly.

Moreover, the adoption of BIM -among other indicators of digitalization- in the most advanced European countries, such as Sweden, is low (Sezer et al., 2021). Only three EU countries have a higher digitalization rate than the United States, as shown in Figure 1: Cyprus, the Czech Republic and the Netherlands.



Source: Own elaboration.

Figure 2. Infrastructure digitalization rate in 2019 in the 27 EU countries, the United Kingdom, the United States and the EU average.

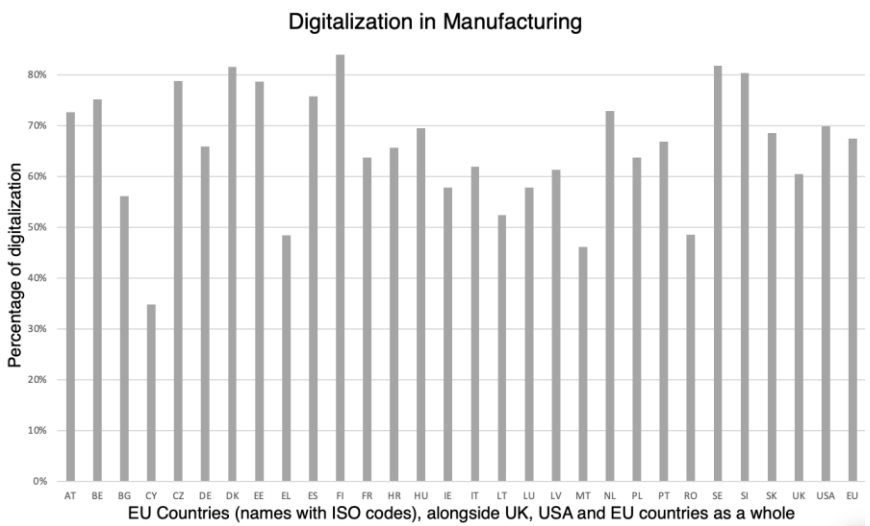
One explanation could be that this is due to a culture within the local construction industries, where innovation is often slow. Even in developed

European countries, BIM maturity is often not higher than level 2. Therefore, there is a key challenge for EU countries: BIM enables faster, cheaper and higher quality construction, and the model that BIM creates can be used for maintenance.

Infrastructures are fundamental to the economy of countries, and the introduction of advanced digital technologies such as Big data or IoT are vital for an optimization of resources (Sadowski, 2022).

As can be seen in Figure 2 and Table 4, the gap between the EU and the U.S. is smaller in terms of digital transformation in the infrastructure sector. Although there is a large deviation in digitalization per EU country, five countries have a higher level than the U.S. The U.K. lags behind, mainly because its investment in the sector has been low over the last few years (Pisu et al., 2015).

Manufacturing has a similar level between the EU and the US, with only two EU countries having less than 50% digitalization, Cyprus and Greece.



Source: Own elaboration.

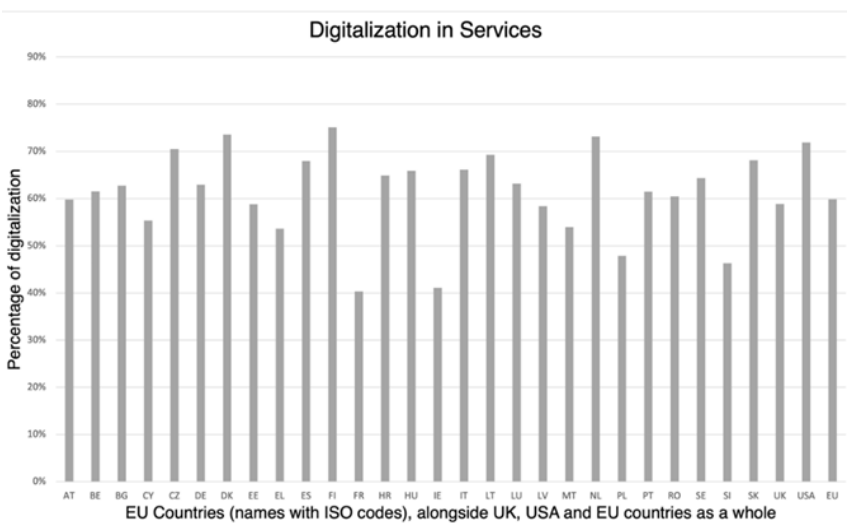
Figure 3. Manufacture digitalization rate in 2019 in the 27 EU countries, the United Kingdom, the United States and the EU average.

The countries with the highest level of manufacturing digitalization in the EU are Czech Republic, Denmark, Estonia, Spain, Finland and Switzerland, all above 75%. Therefore, the level of convergence is increasing in the

European member countries; however, the gap between the EU leaders and those with the lowest scores in manufacturing digitalization is still too large.

However, there are 12 current national initiatives related to digital transformation in industry and manufacturing in the EU, apart from the German one that started the term and the "revolution": the Spanish have 'Industria Conectada 4.0,' the Hungarians the 'National Technology Initiative IPAR4.0,' the Portuguese 'Indústria 4.0,' the Austrians have 'Industrie 4.0 Oesterreich,' Belgium 'Made different - Factories of the future,' the Czech Republic 'Průmysl 4.0,' Denmark the 'Manufacturing Academy of Denmark (MADE),' and Sweden, like the Netherlands, 'Smart Industry' (Sweden also has its Produktion 2030).

The service sector includes many different sub-sectors. Productivity is different depending on the sub-sector, for example, supermarkets tend to optimize large sales with minimal margins. At the same time, they vary in how they measure and optimize output per employee. Digitalization in services is more than 10% higher in the United States than in the EU members as a whole.



Source: Own elaboration.

Figure 4. Rate of digitalization of services in 2019 in the 27 EU countries, the United Kingdom, the United States and the EU average.

As shown in Figure 4 and Table 3, the countries with the highest digitalization in the services sector are Finland, Denmark and the Netherlands. They are the only countries with a higher digitalization rate than the United

States. The countries with the lowest digitalization rate are France, Ireland, Switzerland and Poland. Interestingly, France and Ireland are the countries with the lowest digitalization in this sector, despite having large service companies and high levels of Gross Domestic Product. If we focus on digitally deliverable services, Ireland and France are among the top 10 countries (United Nations Conference on Trade and Development, 2022).

In addition to the lower digitalization of EU members compared to the US, we can see a large difference between countries within the EU. The Netherlands is an example of a highly digitally transformed country, with a higher ratio in all four sectors analyzed. Other countries have a high level of digitalization in some sectors while a poor level in others. Sweden, for example, has a high level in all the sectors studied, except for construction, which is among the least digitalized countries. It is also observable that Germany has a high level of digitalization in the manufacturing sector, as expected due to its industrial power and the implementation of Industry 4.0 (a concept that was not only coined by the country but put into practice by the government and companies in an ambitious plan), but a low level of digitalization in the rest of the sectors analyzed. In this case, it does not seem that Germany has forgotten about digital transformation in other sectors, but has made a significant effort mainly in one sector. Differences in the digital transformation of sectors between countries can be seen as both opportunities and threats. Opportunities can arise when countries are complementary in their digitalization so that the entire EU can diversify their digitalization depending on the country and sector. However, this also poses a threat, as countries could limit themselves to digitalizing only in sectors where they are already competent, thus creating a widening gap between their low levels of digitalization in sectors where those levels are already too low. This could, in turn, become a chronic lack of digitalization in the sectors that need it most.

We saw that there are three levels of digitalization, starting with digitization, going through digitalization and finally digital transformation. We might wonder to what extent the survey accurately represents digital transformation. By asking about advanced technologies, we are capturing more radical changes, but we are not probing into business model innovation, which is a key aspect when assessing the competitiveness of firms (Parida et al., 2019). This remains a key issue to be addressed in a subsequent study. As Parida et al. point out, the value creation, value delivery and value capture components of business model innovation need to be addressed, as well as the sustainability of industry initiatives.

Although the sustainability of companies in the future due to implementation, or lack thereof, is the main focus of this work, environmental sustainability is also necessary and plays an important role in our future as a planet. As an example, most blockchain implementations (e.g., Bitcoin) are energy intensive, generating a large carbon footprint, as their protection mechanisms rely on high power consumption (Beck, 2018, Sedlmeir et al., 2020). Industrial uses of blockchain are widespread and not all are as energy intensive (e.g., Fridgen et al., 2018, Lockl et al., 2020).

Digitalization is based on the availability of more and more electronic components, such as microchips, semiconductors, batteries, etc. The production of these components causes various environmental problems. For example, 98% of the materials used in the production of computers become waste (Berkhout, Hertin., 2004). An important reason is that new materials entering the market displace existing ones.

Traditional criteria on industry optimization, including cost, quality and speed, need to be extended with the concepts of sustainability in ICT (making information and communication technologies themselves more sustainable), and sustainability by ICT (using these technologies to create a sustainable environment for the whole society) (Hilty, Aebischer, 2015).

As we have already mentioned, SMEs are of great importance in the fabric of the EU. However, they often lack the necessary knowledge about advanced digitalization and how they could apply it. They lack the ability to find the right digital technologies for them and have difficulties in managing change, which is necessary to digitally transform themselves. They would need to engage their employees in ICT training, and they also lag behind in digital transformation in terms of management, communication and problem-solving skills. These are key to innovation and technology adoption.

Innovative SMEs and startups are essential for Europe's digital sovereignty and enable sustainable digitalization. As discussed above, they provide the majority of jobs in the European Union. In addition, they help other companies and public administrations to increase efficiency, digitalize their operations and develop green technologies. Therefore, the main focus of digital transformation in the EU should be on SMEs, addressing the differences between countries and trying to spread the digitalization skills of the most competent countries to the rest of them through different mechanisms.

Conclusion

The digitalization is considered as the third industrial revolution. Industry 4.0 and the introduction and implemention of the Internet of Things, Big Data, etc. in companies is key to their success and survival in this digital era. In this piece of research, transformation in EU was compared with other big players such as the UK and USA. With this aim, data were obtained from an annual survey developed by the European Investment Bank and conducted on EU, UK, and USA companies year on year. Data showed that many companies in the EU are less digital than companies in the USA while they are on par with the UK. Specifically, the USA is the more advanced. The higher difference in digital transformation was especially apparent in small and micro companies. However, the difference was nonexistent in Medium companies and Large companies. Focusing on sectors, the highest difference was found in the Construction sector, where EU companies were low in digital transformation compared to the US ones. The most on par sector was the manufacturing one. The importance of digitalization nowadays makes it critical for EU companies to adapt to the more advanced techniques. The lack of digital transformation is a big challenge in Europe, where it lags behind the USA. Thus, critical measures should be introduced to speed up the implementation of advanced technologies in the EU. Furthermore, Innovative SMEs and startups play a key role to Europe's digital success and sustainable digitalization.

References

Alaa, M., Zaidan, A. A., Zaidan, B. B., Talal, M., & Kiah, M. L. M. (2017). A review of smart home applications based on Internet of Things. *Journal of Network and Computer Applications*, *97*, 48–65.

Agarwal, R., Gao, G. G., DesRoches, C., & Jha, A. K. (2010). Research Commentary—The Digital Transformation of Healthcare: Current Status and the Road Ahead. *Information Systems Research*, 21(4), 796–809.

Asghari, P., Rahmani, A. M., & Javadi, H. H. S. (2019). Internet of Things applications: A systematic review. *Computer Networks*, *148*, 241–261.

Beck, R. (2018). Beyond Bitcoin: The Rise of Blockchain World. *Computer*, *51*(2), 54–58.

Berkhout, F., & Hertin, J. (2004). De-materialising and re-materialising: digital technologies and the environment. *Futures*, *36*(8), 903–920.

Chen, F., Deng, P., Wan, J., Zhang, D., Vasilakos, A. v., & Rong, X. (2015). Data Mining for the Internet of Things: Literature Review and Challenges: *International Journal of Distributed Sensor Networks*, 2015.

Chen, B. W., & Ji, W. (2016). Intelligent marketing in smart cities: crowdsourced data for geo-conquesting. *IT Professional*, 18(4), 18-24.

Čolaković, A., & Hadžialić, M. (2018). Internet of Things (IoT). *Computer Networks*, *144*, 17–39.

Colombo, A. W., Karnouskos, S., & Bangemann, T. (2014). Towards the next generation of industrial Cyber-Physical Systems. Industrial Cloud-Based Cyber-Physical Systems*: The IMC-AESOP Approach*, 1–22.

de Fatima Rodrigues, M., Ramos, C., & Henriques, P. R. (1998). Knowledge discovery with retail basket analysis. *Proceedings of the International Conference on Data Mining*, 22, 193–204.

Digitization noun - Definition | Oxford Advanced Learner's Dictionary at OxfordLearners Dictionaries.com. Retrieved April 25, 2022, from https://www. Oxfordlearners dictionaries.com/definition/english/digitization?q=digitization.

EIB Investment Survey. (n.d.). Retrieved April 29, 2022, from https://data.eib.org/eibis/.

European Investment Bank. (2021). *Digitalisation in Europe 2020-2021: Evidence from the EIB Investment Survey*. Retrieved April 29, 2022, from https://www.eib.org/attachments/efs/digitalisation_in_europe_2020_2021_en.pdf.

Fernández-Caramés, T. M., & Fraga-Lamas, P. (2018). A Review on the Use of Blockchain for the Internet of Things. *IEEE Access*, 6, 32979–33001.

Fortune Global 500 2021 | Full list of rankings | *Fortune*. (n.d.). Retrieved May 11, 2022, from https://fortune.com/global500/.

Fridgen, G., Radszuwill, S., Urbach, N., & Utz, L. (2018). Cross-Organizational Workflow Management Using Blockchain Technology-Towards Applicability, Auditability, and Automation. *Proceedings of the 51st Hawaii International Conference on System Sciences*, 3507–3516.

Gartner. (n.d.a). *Definition of Internet Of Things (IoT) - IT Glossary*. Retrieved May 3, 2022, from https://www.gartner.com/en/information-technology/glossary/internet-of-things.

Gartner. (n.d.b). *Definition of Digitalization - IT Glossary*. Retrieved May 7, 2022, from https://www.gartner.com/en/information-technology/glossary/digitalization.

Ghemawat, P. (2001). *Distance Still Matters: The Hard Reality of Global Expansion*. Harvard Business Publishing, 79(8), 1–11.

Grieco, L. A., Rizzo, A., Colucci, S., Sicari, S., Piro, G., di Paola, D., & Boggia, G. (2014). IoT-aided robotics applications: Technological implications, target domains and open issues. *Computer Communications*, 54, 32–47.

Guo, B., Zhang, D., Wang, Z., Yu, Z., & Zhou, X. (2013). Opportunistic IoT: Exploring the harmonious interaction between human and the internet of things. *Journal of Network and Computer Applications*, 36(6), 1531-1539.

Hilty, L., & Aebischer, B. (2015). ICT Innovations for Sustainability. *Advances in Intelligent Systems and Computing*, *310*, 351–365.

Ipsos MORI. (2020). *EIB Group Survey of Investment and Investment Finance*. Retrieved May 20, 2022, from https://www.eib.org/attachments/eibis-methodology-report-en.pdf.

Iqbal, J., Al-Zahrani, A., Alharbi, S. A., & Hashmi, A. (2019). Robotics Inspired Renewable Energy Developments: Prospective Opportunities and Challenges. *IEEE Access*, *7*, 174898–174923.

Iqbal, J., Tahir, A. M., Ul Islam, R., & Riaz-Un-Nabi. (2012). Robotics for nuclear power plants-Challenges and future perspectives. *2012 2nd International Conference on Applied Robotics for the Power Industry*, CARPI 2012, 2012-January, 151–156.

Jung, W., & Lee, G. (2015). *The Status of BIM Adoption on Six Continents*.

Kabugo, J. C., Jämsä-Jounela, S. L., Schiemann, R., & Binder, C. (2020). Industry 4.0 based process data analytics platform: A waste-to-energy plant case study. *International Journal of Electrical Power & Energy Systems*, 115, 105508.

Kahveci, S., Alkan, B., Ahmad, M. H., Ahmad, B., & Harrison, R. (2022). An end-to-end big data analytics platform for IoT-enabled smart factories: A case study of battery module assembly system for electric vehicles. *Journal of Manufacturing Systems*, 63, 214–223.

Kergroach, S. (2020). Giving momentum to SME digitalization. *Journal of the International Council for Small Business*, *1*(1), 28–31.

Khayyam, H., Javadi, B., Jalili, M., Jazar, R. N., Khayyam, H., Jalili, M, Javadi, B., & Jazar, R. N. (2020). Artificial Intelligence and Internet of Things for Autonomous Vehicles. *Nonlinear Approaches in Engineering Applications*, 39–68.

Krotov, V. (2017). The Internet of Things and new business opportunities. *Business Horizons*, 60(6), 831-841.

Lea, G., Ganah, A., Goulding, J., & Ainsworth, N. (2015). Identification and analysis of UK and US BIM standards to aid collaboration. *Building Information Modelling (BIM) in Design, Construction and Operations*, 1, 505–516.

Lockl, J., Schlatt, V., Schweizer, A., Urbach, N., & Harth, N. (2020). Toward Trust in Internet of Things Ecosystems: Design Principles for Blockchain-Based IoT Applications. *IEEE Transactions on Engineering Management*, *67*(4), 1256–1270.

Majchrzak, A., Lynne Markus, M., & Wareham, J. (2016). Designing for digital transformation: Lessons for information systems research from the study of ICT and societal challenges. *MIS Quarterly: Management Information Systems*, *40*(2), 267–277.

Marjani, M., Nasaruddin, F., Gani, A., Karim, A., Hashem, I. A. T., Siddiqa, A., & Yaqoob, I. (2017). Big IoT data analytics: architecture, opportunities, and open research challenges. *IEEE Access*, 5, 5247-5261.

Meng, Q., Zhang, H., & Yu, H. (2018). The Internet of Things-based Rehabilitation Equipment Monitoring System. *IOP Conference Series: Materials Science and Engineering*, 435(1), 012015.

Molaei, F., Rahimi, E., Siavoshi, H., Afrouz, S. G., & Tenorio, V. (2020). A Comprehensive Review on Internet of Things (IoT) and its Implications in the Mining Industry. *American Journal of Engineering and Applied Sciences*, 13(3), 499–515.

Ng, I. C., & Wakenshaw, S. Y. (2017). The Internet-of-Things: Review and research directions. *International Journal of Research in Marketing*, 34(1), 3-21.

Parida, V., Sjödin, D., & Reim, W. (2019). Reviewing Literature on Digitalization, Business Model Innovation, and Sustainable Industry: Past Achievements and Future Promises. *Sustainability 2019, Vol. 11, Page 391*, *11*(2), 391.

Parviainen, P., Tihinen, M., Kääriäinen, J., & Teppola, S. (2017). Tackling the digitalization challenge: how to benefit from digitalization in practice. *International Journal of Information Systems And Project Management*, 5(1), 63-77.

Plattform Industrie 4.0 - Homepage. (n.d.). Retrieved April 26, 2022, from https://www.plattform-i40.de/IP/Navigation/EN/Home/home.html.

Pisu, M., Pels, B., & Bottini, N. (2015). Improving infrastructure in the United Kingdom. *OECD Economics Department Working Papers*, No. 1244.

Reka, S. S., & Dragicevic, T. (2018). Future effectual role of energy delivery: A comprehensive review of Internet of Things and smart grid. *Renewable and Sustainable Energy Reviews*, 91, 90–108.

Sagiroglu, S., & Sinanc, D. (2013). Big data: A review. *Proceedings of the 2013 International Conference on Collaboration Technologies and Systems*, CTS 2013, 42–47.

Salminen, V., Ruohomaa, H., & Kantola, J. (2017). Digitalization and big data supporting responsible business co-evolution. In *Advances in human factors, business management, training and education* (pp. 1055-1067). Springer, Cham.

Shabana, N., & Velmathi, G. (2018). Advanced tele-surgery with IoT approach. *Lecture Notes in Electrical Engineering*, 492, 17–24.

Sestino, A., Prete, M. I., Piper, L., & Guido, G. (2020). Internet of Things and Big Data as enablers for business digitalization strategies. *Technovation*, 98, 102173.

Sezer, A. A., Thunberg, M., & Wernicke, B. (2021). Digitalization Index: Developing a Model for Assessing the Degree of Digitalization of Construction Projects. *Journal of Construction Engineering and Management*, 147(10), 04021119.

Sadowski, B. (2022). Book review: A Modern Guide to the Digitalization of Infrastructure. *Digital Policy, Regulation and Governance*, *24*(2), 220–224.

Sapaty, P. S. (2015). Military Robotics: Latest Trends and Spatial Grasp Solutions. *International Journal of Advanced Research in Artificial Intelligence*, *4*(4).

Sedlmeir, J., Buhl, H. U., Fridgen, G., & Keller, R. (2020). The Energy Consumption of Blockchain Technology: Beyond Myth. *Business and Information Systems Engineering*, *62*(6), 599–608.

Sestino, A., Prete, M. I., Piper, L., & Guido, G. (2020). Internet of Things and Big Data as enablers for business digitalization strategies. *Technovation*, 98, 102173.

United Nations Conference On Trade and Development (2022*).* Digitalization of Services: What Does It Imply to Trade and Development? Retrieved May 11, 2022 from https://unctad.org/system/files/official-document/ditctncd2021d2_en.pdf.

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, 122, 889–901.

Volk, R., Stengel, J., & Schultmann, F. (2014). Building Information Modeling (BIM) for existing buildings — Literature review and future needs. *Automation in Construction*, 38, 109–127.

Wanasinghe, T. R., Gosine, R. G., James, L. A., Mann, G. K. I., de Silva, O., & Warrian, P. J. (2020). The Internet of Things in the Oil and Gas Industry: A Systematic Review. *IEEE Internet of Things Journal*, 7(9), 8654–8673.

Weber, R. H., & Weber, R. (2010). *Internet of Things* (Vol. 12). Heidelberg: Springer.

Wortmann, F., & Flüchter, K. (2015). Internet of Things. *Business & Information Systems Engineering*, 57(3), 221-224.

Zanella, A., Bui, N., Castellani, A., Vangelista, L., & Zorzi, M. (2014). Internet of Things for smart cities. *IEEE Internet of Things Journal*, *1*(1), 22–32.

Chapter 3

Digitalization through ICT Innovation: Analysis of the Impact of Factors on R&D Investment Decisions of Technological Companies

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Abstract

Digitalization, considered as a global trend and the growth engine of the modern economy, implies the use of disruptive technology. The availability of technologies and their updating necessarily involves companies from the ICT sector, which means that technological innovation is critical. This requires a strategy that involves corporate R&D investments, which are not always maintained at the desired levels.

In this context, the objective of this research is to determine the impact generated by different factors on R&D investment by ICT companies. The sample used 1,264 listed ICT companies from 22 countries, 14 of which are European, with complete financial data for the period from 2016 to 2018. The analysis was performed using a univariate model estimated by generalized least squares (GLS). The first group of independent variables are firm-level, which include cash flow, long-term debt, profitability, trade credit, size, growth opportunities, fixed investment and previous R&D expenditures. The second group includes

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macroeconomic variables, such as GDP growth, inflows of Foreign Direct Investment (FDI) and Business Expenditure in R&D (BERD).

The empirical analysis includes five models that help us understand the main patterns of the technological companies regarding their decision to invest in innovation. The first part of the analysis includes the global model applied to all the sampled companies. It explains that cash flow and fixed assets limit corporate R&D investment, while size, growth opportunities, previous R&D investment and GDP growth favor it.

The second part of the analysis comprises four models with the following classifications: by sector (ICT manufacturing vs. ICT service), growth opportunities (low vs. high), GDP spending on R&D (weak vs. strong contribution for R&D) and region (European vs. non-European countries). In all these models, cash flow and previous spending on innovation are the most important determinants of the decision to invest in R&D. In the rest of the models the results are similar, although certain differences can be observed. For instance, for companies with low growth opportunities, both cash flow and long-term debt are ineffective as a source of financing for their R&D activities. FDI inflows favor corporate R&D investment only in the companies located in the more innovative countries, with GDP spending on R&D over 3%. Finally, profitability is only relevant for European ICT companies, for which it looks like an alternative way of financing their R&D activities.

These findings provide a better perspective on the development of the European ICT sector and the R&D investment performance of its companies. This information can also be helpful for a wide range of stakeholders, such as shareholders, managing board, suppliers of ICT companies and Public Administration to establish and execute strategies for optimal management of R&D investment of technological firms.

Keywords: Europe, digitalization, innovation, R&D investment, ICT companies, GLS model

Introduction

Digitalization sets a frame which requires a solid innovative foundation through the use of different new technologies (Rachinger et al., 2018). Digitalization ensures competitiveness for companies and entire nations. Nowadays, it is considered a global trend and the growth engine of the modern economy. It is stressed that digitalization requires extensive use of technological solutions, such as alternative energy sources, nanomaterials, biomedical and 3D printing solutions, just to name a few (Kravchenko et al.,

2019). Consequently, digitalization heavily relies on technological innovation, which generates a positive relationship between digitalization and the use of technology (Yang et al., 2021). This creates a specific challenge for tech firms because they must innovate continuously to ensure that current technological solutions fit the requirements of a digital economy. In this regard, we will refer to tech firms as those belonging to the sector of Information and Communication Technologies (ICT).

In this chapter we would like to analyze the behavior of ICT companies regarding such strategic questions as investment in innovation. To proceed with this analysis, we focus on the outputs of innovation, included in the process called research and development, abbreviated as R&D. Many companies try to undertake different kinds of activities based on R&D, which usually adopts a shape of specific projects. This generates positive impact on the entire process which involves product innovation, patent creation, and management (Mairesse and Mohnen, 2004). In addition, companies that invest more in innovation have more opportunities to expand their business and grow faster (Wang, 2010; Choi et al., 2015; Kumar and Li, 2016).

In summary, both the process itself and the final decision look very simple: if your company applies more effort in innovation, it will be more successful in the market, because the new technological solutions will generate a new demand and this will make the company grow. But this question is much more complex in the real world. It requires accurateness in planning and execution, and, even with more than excellent management, the company has to deal with a lot of uncertainty. So, what makes ICT companies invest more or less in R&D? Surely, there are many different factors, inside or outside the company, that influence innovation investment decisions in one way or another.

To start with the analysis, let us correctly define what R&D means. Following the Frascati manual, R&D is considered a part of scientific and technological activities (STA) and refers to R&D expenditures which cover different resources including human resources allocated to these activities. It is important to note that R&D in this case is specific and excludes education, other scientific, technological, industrial and supporting administrative activities. Exactly, it can be defined as follows:

> Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. (Frascati, 2002, p.31)

When an organization decides to invest in R&D, it needs to plan many different activities that help create, produce, diffuse and apply specific knowledge (Wang, 2010). So, the purpose of R&D is to generate knowledge, in a broad sense, and apply it to solve real-world challenges and problems. This process may require basic and applied research, aimed at the acquisition of new knowledge and also development based on the previous knowledge obtained through research or experience (Frascati, 2002; OECD, 2015).

R&D investment made by companies is a recurrent topic in the literature (e.g., Mulkay et al., 2001; Guellec and Van Pottelsberghe De La Potterie, 2003; Bond et al., 2005; Bloom, 2007; Harris and Trainor, 2009; Coad and Rao, 2010; Becker, 2013). Some of the studies highlight a close relationship between R&D effort and development of ICT, which enables economic growth (Nair et al., 2020). Actually, investment in innovation frequently requires previous investments in technology, which sets the ground for R&D activities within a company, improves the results and generates additional value for business (Bardhan et al., 2013). In this regard, Coccia (2015) explains that the decision to invest in R&D frequently refers to the development of new technologies or intermediate solutions somewhere between old and new technological achievements. In this way, as stated previously by Bryan et al. (2007), a company is able to optimize product development costs and respond effectively to market changes.

R&D investment generates more impact in technological companies than in other industries. In this regard, much research has been done on R&D made by ICT firms, focusing mainly on the impact it generates on productivity (Koutroumpis et al., 2020) and business performance (Koutroumpis et al., 2017; Hunady et al., 2020). Apparently, ICT companies obtain better results when they carry out R&D activities on a continuous basis and not occasionally. This approach allows them to obtain an improved development of a technological product, which can be widely used due to a better comprehension of its application and cost reduction for the users (Dedehayir and Steinert, 2016). Besides that, constant R&D effort enhances technological change and its wide adoption.

With all this in mind, we must take into account that R&D is the initial stage of a technology life cycle and involves high risk and costs. When a technological solution is reasonably successful, this can be seen through its commercialization, so the initial costs will be recovered and, later, at the maturity stage, higher profits will be obtained (Cao and Zhao, 2011). But if the results of the R&D effort are weak and unconvincing, a company will have

to assume all the costs. This will reduce possible earnings jeopardizing the sustainability of the company.

So, R&D activities require serious planning and execution. Actually, we must speak in terms of R&D investment, which is a complex issue that involves two kinds of decisions: investment and financing. Mainly, the key is how much to invest in innovation in order to reach the optimal level and what kind of funds to use for these assets. To answer this question, it is important to take into account that R&D investment is long-term. As stated by Usman et al. (2017), it becomes more mature and sustainable after the second year.

Despite the importance of R&D, relatively little research has been done on what affects the decision of tech companies to invest in innovation. There are several studies focusing on the effect generated by certain factors, frequently, firm-level ones, such as cash flow, leverage, performance or size. Nevertheless, there is scarce or even non-existent research regarding simultaneous effect of firm-level and macroeconomic variables, such as country and industry-level factors, on R&D investment as dependent variable. In our study we focus on a wide range of these factors trying to determine causality of these two big groups of variables on R&D investment decisions of ICT companies located in Europe and in other regions.

The findings of this study contribute significantly to the literature by providing the following novelties: (1) the analysis focuses on the effect of firm-level as well as of macroeconomic factors on the decisions of ICT firms to invest in R&D; (2) the analysis uses a large sample of ICT listed companies from 22 countries, what provides specific information on the behaviour of European vs. non-European firms; (3) the election of the Generalized Least Squares (GLS) method for estimation proves to be efficient in the presence of heteroscedasticity; (4) the comparison among different groups of ICT companies sheds light on the particular factors that favor or hinder corporate R&D investment; and (5) the results can help design and establish measures and policies to improve support for R&D investment made by ICT companeis worldwide.

The rest of the chapter is structured in the following sections. Section 2 makes a literature review and analyses the different appoaches to R&D, highlighting the way the innovation is managed in ICT companies. Section 3 and Section 4 present the sample and the methodology used in the empirical analysis. Section 5 explains the results obtained from the analysis. Lastly, Section 6 presents the main conclusions drawn from the research.

R&D by ICT Companies: What Its Influences and What It Is Influenced By

R&D investment is a considerable part of the effort applied by ICT firms regarding their expansion and growth. Actually, it represents a large proportion of all investment made by ICT companies (Aoun and Hwang, 2008). There are evidences suggesting that firms from more competitive industries invest more in R&D (Kathuria, 2008). So, tech companies are expected to follow this pattern, since the ICT industry is considered as amongst the most competitive ones (Marinković et al., 2018).

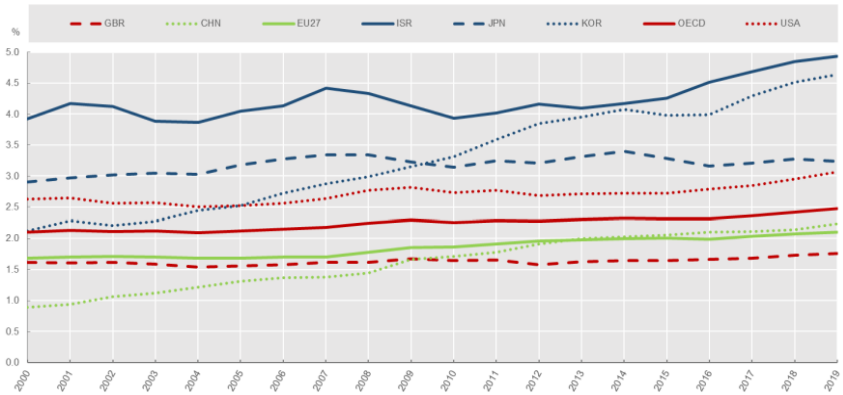
Investment in R&D is fundamental since it is positively related to capitalization and economic performance, as demonstrated by Postula and Chmielewski (2019) in their analysis of European ICT firms. This effect is mostly noted in the ICT manufacturing sector as highly intensive in R&D. Particularly, the increased profit is observed mainly in those companies that invest previously in R&D, as shown in the example of semiconductor companies (Shen et al., 2017).

This is related to the intensity with which innovation grew over the last two decades worldwide. R&D expenditure, measured as a percentage of GDP, grew in real terms by 4% in the OECD countries in 2019, according to the latest statistics. This increase is mainly due to the contribution of the United States, Germany and Korea. Israel accounts with the highest level of R&D intensity at 4.9% of their GDP. China and the EU27 group of countries show lower results reaching only 2.2% and 2.1% of increase; both regions are still far from the 3% fixed as a goal for the OECD countries (see Figure 1 and Figure 2).

Regarding the share of the European ICT sector in business spending on innovation, as a proportion of the global business expenditures in R&D, Montenegro, Cyprus and Estonia show the highest level. The countries in which the ICT sector invests considerably less in R&D are Germany, Ireland and Poland (see Figure 3).

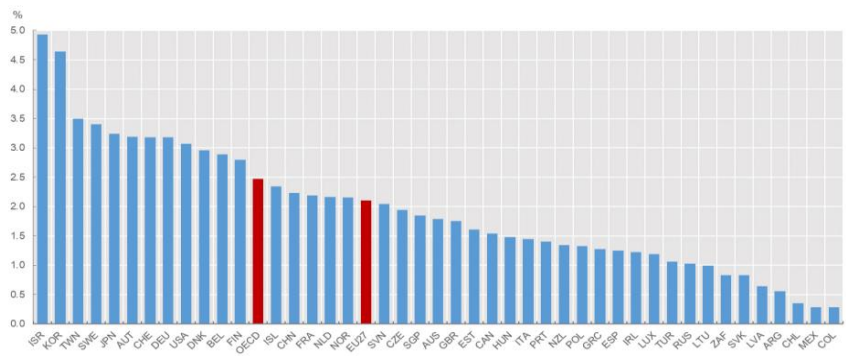
The previous results are correlated with the value added for the European ICT industry, which grew in almost 42% for the ICT manufacturing and 28% for the ICT service industries from 2014 to 2019 (see Figure 4).

The investment in innovation is characterized by “sunk costs and large fluctuations in the level of spending” (Bond et al., 2005, p.436) and also by additional costs related to specific investments and low collateral value (Succurro and Constanzo, 2016). This is because the assets resulting from R&D activities of firms are intangible, with uncertain economic value.



Source: retrieved from the OECD Main Science and Technology Indicators (MSTI) database.

Figure 1. R&D intensity, as gross domestic expenditure on R&D as a percentage of GDP, 2000-2019.



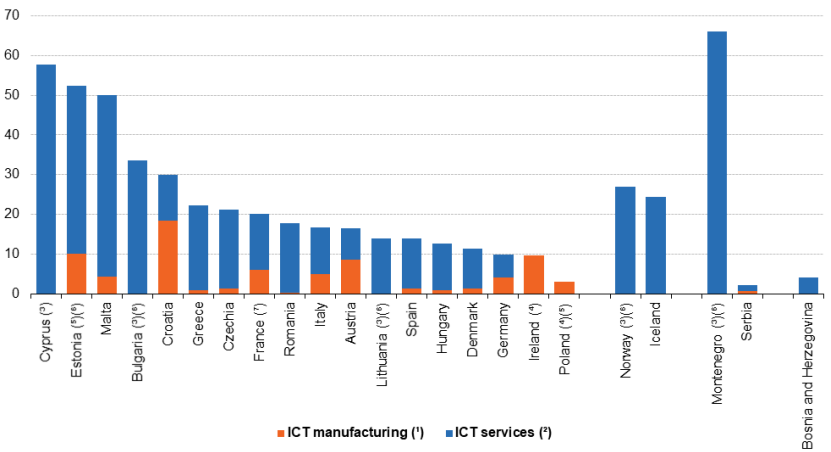
Source: retrieved from the OECD Main Science and Technology Indicators (MSTI) database.

Note: For Chile and Singapore, data refer to 2018. For Argentina, Australia, New Zealand, South Africa and Switzerland, data refer to 2017.

Figure 2. R&D intensity, as a percentage of GDP, in OECD countries and selected economies, 2019.

This limits their use as collateral in bank loans and other similar financing instruments (Laborda et al., 2020), what generates additional pressure for the company. Some of the examples in which this pressure materializes are the higher costs that innovative companies have to bear. That is, higher marginal costs associated to debt (Chiao, 2002) and, generally, high adjustment costs

(Mikkelson and Partch, 2003). The decision to invest in R&D also compromises the company's short-term economic results (Driver and Guedes, 2012) and liquidity (Succurro and Costanzo, 2016). So, the companies that plan to carry out R&D activities need to manage more effectively the associated risks.

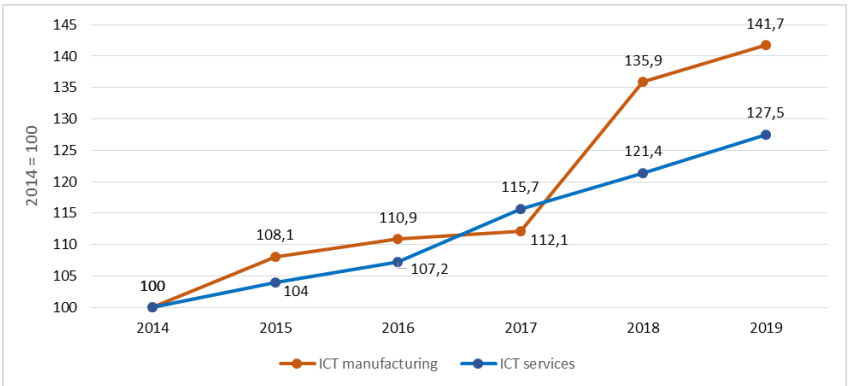


Note: EU Member States not shown present partial or confidential and non available data.
Data for Denmark: 2019 provisional. Data for Hungary: 2019 definition differs.
(1) Excluding the manufacture of magnetic and optical media (NACE Group 26.8)
(2) Excluding the repair of computers and communication equipment (NACE Group 95.1)
(3) ICT manufacturing: confidential or non available data.
(4) ICT services: confidential or non available data.
(5) ICT manufacturing: 2018
(6) ICT services: 2018
(7) ICT manufacturing and services: 2017

Source: retrieved from Eurostat.

Figure 3. Share of the ICT sector in business spending on R&D (in %), selected European countries, 2019.

It is important to take into account that R&D, on the one hand, requires investment in other tangible and intangible assets, such as facilities, machinery, hardware, software or technology. On the other hand, R&D leads to an increase in wages, since this activity requires hiring new personnel with specific knowledge and experience, such as scientists and engineers (Hall and Lerner, 2009). In fact, the qualified personnel needed for R&D-based projects is one of the major expenses (Brown and Petersen, 2011). The output of these projects is knowledge, which is considered as an intangible investment and difficult to collateralize (Baldi and Bodmer, 2018). Consequently, the firms that wish to invest in R&D face the additional challenge of managing increased expenditures and low collateral (Bloch, 2005).



Source: own elaboration based on the statistics of Eurostat.

Figure 4. Development of value added for the ICT sector in EU, 2014-2019.

If the companies that invest in innovation have insufficient cash flow, they need to struggle with the difficulties related to the access to external financing. This is because these companies present low security and high information asymmetry (Bond et al., 2005; García-Quevedo et al., 2017). Low security is related to the companies, due to their limited liability, usually assuming higher risks when they plan to undertake innovative projects. It is also related to uncertain results generated by R&D activities. This asymmetry is due to companies having better information about their R&D-based projects and expected result than the suppliers of funds. But disclosing this information, considered as strategic, is critical for the companies since they can lose their competitive advantage (Bloch, 2005). In addition, a company has a perfect knowledge of the allocation of the external funds it receives, but this information is not available for the lenders. This creates moral hazard problems (Myers and Majluf, 1984; Svensson, 2013). It is especially harmful for long-term debt, since it does not include periodical control by lenders.

The above-mentioned factors create certain constraints that slow down the development of innovation in companies. Actually, if a company does not perform innovative activities, it may be due to liquidity uncertainty (Beladi et al., 2021), the impossibility of accessing external capital and excessive costs related to financing and management (Pellegrino and Savona, 2017). But it also happens because of managerial decisions to reject R&D-intensive projects, since they are less preferable for managers, as stated by agency theory (Jensen and Meckling, 1976). This leads to underinvestment in R&D (Lee and O'neill, 2003).

Innovation is difficult to finance for any company and, more specifically, for tech companies that usually apply greater effort in this sense, as pointed out by Succurro and Constanzo (2016). Besides that, ICT companies deal with different types of R&D-based project, which may reduce or increase the associated risk. For example, when dealing with cutting-edge innovation, a company is more likely to obtain a more successful product compared to more routinely innovative projects. But the duration of these more promising projects is quite long (Baldi and Bodmer, 2018). This increases associated risk and requires foreseeing the use of the most affordable and the least costly source of financing.

In this context, it is believed that the main obstacles for innovation in a company are financial ones. Actually, these are relevant since companies need to plan whether they will finance their R&D activities with their own funds generated through profits, using cash holdings, asking for bank loans or raising equity. The access to any of these financing sources and their availability will determine the scope of innovative activities that can be undertaken by the companies.

However, it is also important to take into account other factors which influence R&D investment. There are firm-level variables beyond financial ones (cash flow or leverage), such as company size and growth opportunities. Besides that, it is quite interesting to explore the influence of the previous effort made by a company in R&D and investment in fixed assets. Finally, certain macroeconomic variables are likely to condition R&D investment of ICT companies. For example, we expect to obtain significant results in the analysis of the effect generated by the economic growth of a country, inflow capitals of foreign direct investment and an effort of business sector for innovation in each country.

Following the traditional focus of a large number of research studies, first we are going to summarize the main ideas expressed in the literature about the impact of different financial factors: cash flow, debt, profitability and trade credit.

The level of cash flow, or liquidity, is one of the most relevant factors having a major impact on strategic corporate decisions, such as investment (Love, 2003; Fazzari et al., 2008). Cash flow may serve as an indicator of a future profitability that a company expects to obtain (Bond et al., 2005). When a company is financed through cash flow, its investment capacity increases because the presence of cash flow makes the company less financially constrained (Bolton et al., 2011). Additionally, we should take into account that the internal funds are associated with smaller costs than the external ones.

Besides that, managers are more likely to spend cash flow in the first place (Lewellen and Lewellen, 2016). So, generally, companies with strong cash flow can afford investing more.

A similar relationship is expected regarding R&D investment (Mikkelson and Partch, 2003). This is because the intangible nature of R&D reduces company access to debt and makes them rely more on cash holdings (Baldi and Bodmer, 2018). Actually, liquid companies usually continue smoothly with their expenditures in R&D since cash flow allows them to protect themselves against financial shocks and also reduce adjustments costs (Brown and Petersen, 2011). In this sense, a great number of research studies reported a positive significant relation between cash holdings and R&D investment. This stresses the relevance of internally generated funds to finance innovative activities (Brown and Petersen, 2009; Czarnitzki and Hottenrott, 2011; Brown et al., 2012; Baum et al., 2013; Brown and Petersen, 2015). This is especially relevant for ICT companies that carry out cutting-edge R&D projects, which are long-lasting and riskier. This forces them to ensure the availability of higher cash flow to be able to cope with costly contingencies (Baldi and Bodmer, 2018).

Relying on Myers (1984) and Myers and Majluf (1984), the asymmetric information, as one of the market imperfections, makes a company establish a hierarchy in the use of funds for its innovative projects. So, internally generated funds will be the first option, followed by debt as external finance. It is equally important to consider equity finance for R&D-based projects, as suggested by Opler and Titman (1994), since companies are not required to show collateral. Besides that, equity issuance does not increase the probability of financial distress for a firm. This idea is also supported by Carpenter and Petersen (2002) and Brown et al. (2012), since debt and cash are highly volatile, which significantly increases R&D adjustment costs. But it may depend on the country in which a company is located, since its orientation towards bank or market support influences greatly on a company's election between debt and equity (Sucurro and Costanzo, 2016). The outcome can also depend on the financial constraints of the company itself. If it has limited access to external funds and is not able to generate enough cash flow, equity might be a solution, provided that an R&D-based project is likely to be successful (Alkhataybeh, 2021).

The effect generated by cash flow on R&D may depend on some other aspects. For example, it is observed that small and medium-sized firms, especially in the presence of informative asymmetry and financial constraints, make a more intensive use of cash holdings to support innovative activities

(Shin and Kim, 2011), while in large companies this effect is minimal (Brown et al., 2009) or even insignificant (Arikawa et al., 2011). Regarding innovative development of a country, there also may be differences. As shown by Veugelers (2016), the relation between cash holdings and R&D investment is expected to be significant in those countries classified as innovation leaders, typically more advanced economies. However, for less innovative countries the impact of cash flow on R&D may be weak.

Certain studies show that current cash holdings have high cost generated through interest taxes and can be allocated for other corporate needs. Alkhataybeh (2021) is more categorical suggesting that cash flow is not a proper source of financing for such a particular investment as R&D. Following these arguments, cash holdings reduce R&D investment (Kim et al., 1998; Almeida et al., 2004), although this behavior is more observed in financially constrained companies (Brown and Petersen, 2011). Probably this is because cash holdings are allocated preferably to fixed investment and also short-term obligations.

Debt is another financial variable that determines a company's investment capacity. According to the trade-off theorem, companies tend to ensure an optimal capital structure when making a decision on funding. In this sense, debt proves to be an attractive source of financing for companies because it makes it possible to offset tax and agency benefits against the cost of debt. In addition, debt is a good resource for growing investments, and this serves to increase the value of the company (Modigliani and Miller 1963; Myers 1977; Fama and French, 2002; Benito, 2003; Al-Kahtani and Al-Eraij, 2018). A higher level of indebtedness, moreover, would help to reduce the problems derived from excessive cash flow, according to agency theory (Jensen, 1986). The results of other studies also support the idea that companies with higher leverage invest more, but they highlight that this happens with those investments that offer more security or more liquidity (Almeida et al., 2011). So, this outcome could be different when we speak about R&D investment due to that they are less stable and highly risky.

Based on other classical theories, high debt levels can hamper different investments due to agency problems and bankruptcy risk arising from the use of debt (Myers, 1977; Hart and Moore, 1994; Whited, 2006). In addition, due to the presence of certain macroeconomic factors, the nominal interest applied to debt can become high, which will reduce the level of cash flow. Consequently, corporate investment capacity decreases (Fazzari et al., 2008). Therefore, debt can be seen as a factor that increases the risk level of the

company and, consequently, ends up negatively affecting investment decisions (Ozdagli, 2012).

What is considered a strong financing source for corporate R&D investment, especially in bank-based countries, is a long-term debt (Boot, 2000; David et al., 2008). Nevertheless, different empirical studies point at that highly leveraged firms invest less in R&D (Simerly and Li, 2000; Singh and Faircloth, 2005). But it may depend on the country in which it happens. Bhagat and Welch (1995) found negative relationship between debt and R&D in the companies located in the United States, positive in Japan and insignificant in Canada, United Kingdom and Europe.

Alkhataybeh (2021), in his research on the management of R&D investment of the listed firms on the Tel Aviv Stock Exchange, shows that the effect generated by debt on R&D effort is negative, but insignificant. Additionally, we should also consider the period under analysis. According to the results of Arikawa et al. (2011), in Japan the impact of debt on R&D investment was found negative from 2001 to 2008 and in the late 1990s, while in the late 1980s it was insignificant.

Finally, taking into account the heterogeneity of companies and a long-term debt as a specific financing instrument, Chiao (2002) found that the relationship between debt and R&D investment was negative only for science-based companies and positive for the rest. These results suggest that innovative technological companies probably do not follow any traditional model, such as trade-off or pecking order theory, to finance R&D investment. Instead, they adopt different strategies to solve their innovation needs depending on the country's characteristics and the timing of the decision.

Another variable that can influence a company's investment decisions is its profitability, which is associated with its capacity to generate internal funds through profits. Profitability is one of the fundamental parts of corporate finance and key performance indicators in business management. Following the pecking order theory, a profitable firm has a greater availability of internal funds that it will use first (Myers and Majluf, 1984; Frank and Goyal, 2009). In this regard, Rajan and Zingales (1995), in their empirical analysis of the determinants of capital structure in listed companies of many different countries, found that profitable companies usually have less debt. The firms that are likely to generate and retain more profits are large and mature, so they have less need to resort to external financing than younger firms (La Rocca et al., 2011). This may signal that generally available earnings are used to support strategic decisions, and investment in innovation is one of them. In this regard, it was found that if a company ensures a high business

performance, it can boost corporate R&D expenditure in the next year, as shown in the studies of Ali-Yrkkö (2004) and Simanjuntak and Tjandrawinata (2011), and even in the same year (Roucan-Kane et al., 2007).

Nevertheless, it was also found that profitability can generate a negative effect on R&D (Hitt et al., 1991; Chen and Miller, 2007) or insignificant (Bhattacharya and Bloch, 2004; Manganelli, 2010). Possibly, the companies with increased profitability decide to assume less risk in their future projects, like in R&D-based ones. This is due to that these projects generally negatively affect business performance in terms of profitability, although this depends on the economic development of a country (Usman et al., 2017). Maybe companies need to prepare for such decisions in advance by foreseeing measures to counteract the negative consequences.

Trade credit, another factor that can influence R&D investment decision, is credit extended by a supplier allowing delayed payment of the products and services sold (Biais and Gollier, 1997). The importance of trade credit as external source of short-term financing is stressed in many studies (e.g., Danielson and Scott, 2004; Guariglia and Mateut, 2006; Ogawa et al., 2013) since it can reach up to 30% of total debt, as shown by Carbo-Valverde et al. (2016) in their study of US small and medium enterprises. Trade credit acts as a complement to debt (Ono, 2001) and is one of the most expensive financing sources (Plötscher and Rottmann, 2002; Czarnitzki, 2005). Actually, it is considered as "a last resource for funding under more extreme circumstances," as Love et al. (2007, p.453) explain in their research analyzing the effect of the crisis on listed companies in Asia and Mexico. The authors add that financially vulnerable companies are more likely to use trade credit, as long as suppliers allow them for this opportunity. Apparently, companies can even replace debt by trade credit when debt is not available for them (Nilsen, 2002; Fisman and Love, 2003).

Regarding investment in innovation, the relationship between trade credit and R&D is not very clear. Czarnitzki (2005) explains that the dependence of companies on trade credit does not generate any significant effect on R&D investment. So, having good or bad trade-credit rating will unlikely influence the decision to start an R&D-based project.

Firm size is another critical factor that determines R&D investment (Damanpour, 2010). Traditionally, as observed in many other sectors, the larger the company the larger the R&D effort (Kathuria, 2008; Zona et al., 2013). This can be explained by the fact that market distribution is dominated by large companies that are more productive because they have more opportunities for innovation. However, smaller companies face much larger

difficulties to manage innovation (Coad et al., 2016), mainly, due to greater asymmetric information (Succurro and Costanzo, 2016) and limited access to the specific resources related to R&D (Hölzl et al., 2010).

The reason behind this is that smaller companies have limited assets and are less leveraged, while larger firms can afford partial financing of R&D projects through debt (Arikawa et al., 2011). This happens because larger companies have a historical record of repaying debt and a larger number of tangibles, which can be considered as collateral. All this facilitates them access to external funding for R&D projects (Baldi and Bodmer, 2018). Besides that, larger companies are more diversified, so they are better prepared to assume possible negative results from R&D activities (Muhammad et al., 2022).

Nevertheless, it has been observed that smaller companies are likely to grow faster since they are able to assess financial strategic decisions properly and in a timely manner (Honjo and Harada, 2006; Moreno and Casillas, 2007). They look like adapting better and more effectively to external conditions than larger firms (Serrasqueiro et al., 2010). Besides that, it has been observed that many start-ups and small ventures are very relevant in the knowledge economy since they are extremely innovative (Pederzoli et al., 2013). Maybe in ICT sector the size is a good predictor of the firms' investment decisions, but it is not very clear that it is so in regard to R&D investment.

The growth opportunities that a company may have represent another factor that influences investment decisions. According to the classical theory of investment (Tobin, 1969), companies with increased growth opportunities invest more. Higher business opportunities facilitate access to external financing (Love, 2003) and are associated with the generation of competitive advantage and new assets (Scheutz and Hägg, 2006). According to Aivazian et al. (2005) and Anderson and Garcia-Feijóo (2006), if a company has profitable growth opportunities, its investments are expected to increase. High business opportunities correspond to the expectation of obtaining high cash flow or profits in the future. This minimizes the problems of adverse selection and moral hazard and influences investments in a positive way.

It has also been observed that firms' growth opportunities are positively related to R&D investment (Youndt et al., 2004; Guariglia, 2008). So, a company with more business opportunities is expected to increase its R&D expenditures, although the results may be influenced by the analyzed period and the age of the companies (Brown and Peterson, 2011). Besides that, the intensity of this investment depends on other firm-level characteristics and also on industry, as explained by Van Vo and Lee (2017). The authors add that

in more competitive markets, growth opportunities should be seized immediately, which is usually done through initial R&D investment considered as strategic.

R&D investment can also depend on fixed investment, such as investment in new capital goods. But, the dominant type of research is focused on the influence of R&D on fixed investment. For example, Baussola (2000) found that R&D induces higher investment in machinery or equipment, which is finally correlated with increased profitability of a company and market share. Other studies stress that this relationship is strong because innovation requires specific assets, such as physical facilities (Carboni and Medda, 2019). At this point, these two types of investment are complementary. Nevertheless, there is little research specifically focused on the impact generated by fixed investment on R&D. In Baussola's study mentioned above, the author suggests that this relationship is expected to be significant in the long run, when innovation is needed for improved maintenance of fixed assets, such as plants, and their contribution for product development. So, possible effects would be seen after a certain period of time. However, Filatotchev and Piesse (2009), in their analysis of newly listed companies, say that previous capital investment influences negatively R&D activities except for companies with low debt and a large stock of intangible assets (in this case they are likely to invest in R&D).

Finally, the previous effort in innovation made by a company positively influences corporate R&D investment in the current year, according to the models introduced by Brown et al. (2009) and Brown and Petersen (2011). Apparently, a company invests more in R&D if it has done it previously (Busom, 2012; Shen et al., 2017). This may be explained by the inertia effect of the past experience in carrying out innovative activities (Zong, 2022). It is also important to take into account that R&D investment done in the past decreases barriers and costs to continue with innovative projects (Chinloy et al., 2020).

GDP growth, as a macroeconomic variable, is closely related to investment decisions. In fact, private sector companies consult this parameter as a benchmark of investment climate in their country (Van den Bergh, 2009). Economic growth is related to higher capital formation (Carroll and Weil, 1994; Blomström et al., 1996). In contrast, low levels of investment correspond to weak economic growth coupled with higher inflation and uncertainty (Fischer, 1993). Regarding investments related to technological development, it is detected that the relationship between economic growth and this investment as well as the causal nexus vary according to the country's

level of development, yielding different results for more advanced and developing economies (Yousefi, 2015).

Focusing more on the ICT industry, the analysis of Beil et al. (2005) of the telecommunications sector in the United States shows that the investments were prominent in this industry due to the good economic development of the country. Therefore, the effect of the country's economic growth on corporate investment decisions of tech companies is expected to be positive. Schmookler (2013) proved this effect measuring the fluctuation of R&D investment as an impact of GDP growth rates. He explained that probably it was because of higher availability of public funds allocated for governmental support of R&D and higher expectations of the companies themselves to improve their economic results. That would certainly help finance R&D investments later. Other analysis of the relationship between economic growth of a country and business investment in innovation, found a positive effect generated by GDP growth on R&D investment, although this causality is not always unidirectional and depends on the level of the country's development (Lam and Shiu, 2010; Sawng et al., 2021).

The inward flow of foreign direct investment, FDI, another macrovariable that can influence the decision to invest in innovation, is an important mechanism for increasing a country's capital stock (Choong & Lam, 2011). The ability to attract foreign capital is one of the factors that helps create a stable economic climate to drive the private sector investments (Agosin and Machado, 2007; Morrissey and Udomkerdmongkol, 2012). FDI opens a channel through which the transfer of capital, technology and knowledge to the host country becomes possible. This helps increase the country's productivity and generates new growth and investment opportunities (Mišun and Tomšík, 2002; Makki and Somwaru, 2004). This positive effect for investments in the host country is also confirmed by the study of Alfaro et al. (2004), which analyzes the relationship between FDI, financial markets and growth from the broadest point of view. But this is possible within the framework of financial stability of the country, which requires the existence of minimally developed financial systems (Borensztein et al., 1998; Choong and Lam, 2011).

FDI is also an effective channel for transference of foreign R&D activities. From this perspective, FDI generates a positive impact on R&D projects undertaken by domestic companies, forcing them to improve quality of technological and managerial processes as well as of outputs (Wang, 2010). The level of local business investment in innovation is expected to increase when the country receives more foreign capitals. Nevertheless, as shown by

the study of Kathuria (2008) of manufacturing firms in medium- and high-tech industries in India, this effect may be conditioned by other economic and political circumstances. It may also happen that domestic companies reduce their R&D investment by taking advantage of the transfer of foreign technologies that act as a substitute for the entire R&D process (Bebczuk, 2002). So, we can expect that companies will adjust their investment behavior increasing or reducing their R&D spending. Finally, other empirical results point out the influence of FDI on domestic R&D investment is insignificant (Varsakelis, 2001).

BERD, another external variable, is Business Enterprise Expenditures in R&D measured as a percentage of GDP. This contribution for innovation from the private sector is what stands behind the total factor productivity (Guellec and Van Pottelsberghe De La Potterie, 2004; Khan and Lunitel, 2006). So, BERD can be considered as an alternative source of funding R&D activities undertaken by the company. It is expected that the higher this support for innovation, the more the company will invest in R&D.

Sample

There has been a significant interest in analyzing what drives and conditions the R&D investment decisions of companies from many different sectors and, more specifically, from the ICT sector. But there is a lack of consistent research on the conjoint impact of different firm-level and macroeconomic factors. Due to this gap and in order to check R&D investment behavior of tech companies, we have conducted an analysis of more than one thousand listed ICT companies located in more than twenty OECD countries. Corporate, accounting and financial information is taken from the S&P Capital IQ database, which contains historical data on a great number of internationally traded companies. Macroeconomic information for each country is taken from the World Bank's World Development Indicators database, the OECD's Main Science and Technology Indicators (MSTI), and the International Monetary Fund (IMF).

The sample includes 1,264 companies from 22 countries with complete information on the data for the period from 2016 to 2018. More than half of these countries are European, but the number of European listed ICT companies is actually only 25% of the sample. America has a similar share, with 26%, while the Asia and Pacific region is highly represented, with 46%. Regarding the countries, a high number of companies are from the United

States, Japan, and Korea, each with approximately 20% of the total sample. In Europe we can distinguish France, Germany, and United Kingdom, whose proportion of the ICT companies ranges from 4% to 5% (see Table 1).

Following Aoun and Hwang (2008), the sample of the companies used includes different subsectors with the following Standard Industrial Classification SIC codes: (manufacturers) 3357, 3571, 3572, 3575, 3577 - 3579, 3651, 3661, 3663, 3671, 3672, 3674 - 3679, 3699, 3823, 3825, 3826; (communications) 4812, 4813, 4822, 4832, 4833, 4841, 4899; (wholesalers and retailers) 5045; (services) 7371 - 7379. All sectors have been grouped into two large groups called the ICT Manufacturing Sector and the ICT Service Sector, which are interdependent on each other (Miozzo and Soete, 2001; Guerrieri and Meliciani, 2005). Table 2 shows the distribution of the companies in these two main sectors.

The sample has a very similar distribution between these two large groups, with 639 companies in the manufacturing sector, representing 50.6% of the total number of companies, and 625 in the service sector (49.5%). The ICT manufacturing sector refers to the manufacturing industry of components, parts, equipment and other elements necessary in the technological sector. Within this group, 142 companies (22.2%) are dedicated to the manufacture and sale of semiconductors and related devices. This activity is of strategic importance due to the generation of specific knowledge, innovation, knowledge transfer and growth opportunities in this technological field (Deng, 2008).

The ICT service sector includes subsectors focused on services and development of software, systems, platforms, computer applications and mobile technologies. It also includes consulting on the introduction and use of technologies in different fields and other additional services. This sector is characterized by being innovative and fast-growing, capable of creating added value through solutions of intangible nature. Most of the companies within the ICT service sector belong to the subsector of computer and software programming and integrated computer systems design: 245 companies representing 39.2% and 126 companies of the service sector representing 20.2%.

The type of innovation created in these two sectors is different. In the service sector, we can find the following particularities which differ very much from the manufacturing sector: (a) co-termination (occurring simultaneously in time and space of production and consumption of the service) between production and consumption (Hill, 1999); (b) the predominant role of use of information and communication technologies (Evangelista, 2000); (c) high

degree of customization (Miles, 2005) leading to intense interaction between the service provider and the user (Hipp and Grupp, 2005) and (d) a high aggregated value of human capital capable of generating advanced knowledge (Gallouj and Weinstein, 1997).

Table 1. Descriptive statistics: ICT companies, distribution by country and region

Distribution by country			
Country	*Region*	*Companies, n*	*% over total*
Australia	Asia and Pacific	25	1.98%
Austria	Europe	6	0.47%
Belgium	Europe	5	0.40%
Canada	America	29	2.29%
Denmark	Europe	7	0.55%
Finland	Europe	13	1.03%
France	Europe	62	4.91%
Germany	Europe	58	4.59%
Israel	Middle East	43	3.40%
Italy	Europe	21	1.66%
Japan	Asia and Pacific	281	22.23%
Korea	Asia and Pacific	265	20.97%
Luxembourg	Europe	6	0.47%
Mexico	America	4	0.32%
Netherlands	Europe	8	0.63%
New Zealand	Asia and Pacific	5	0.40%
Norway	Europe	8	0.63%
Poland	Europe	30	2.37%
Spain	Europe	5	0.40%
Sweden	Europe	38	3.01%
United Kingdom	Europe	49	3.88%
United States	America	296	23.42%
	Total	1,264	100.00%
Distribution by region			
	Region	*Num. companies*	*% over total*
	Europe	316	25.00%
	America	329	26.03%
	Asia and Pacific	576	45.57%
	Middle East	43	3.40%
	Total	1,264	100.00%

Source: Own elaboration.

Table 2. Descriptive statistics: ICT companies, distribution by subsector

SIC Code	ICT MANUFACTURING Sector	Number of companies	% over total MANUF
3826	Analytical instruments	25	3.91%
3578	Calculating and accounting equipment	16	2.50%
3576	Computer communications equipment	26	4.07%
3577	Computer peripheral equipment	38	5.95%
3572	Computer storage devices	5	0.78%
3575	Computer terminals	2	0.31%
3677	Electronic coils and transformers	4	0.63%
3679	Electronic components	61	9.55%
3571	Electronic computers	5	0.78%
3678	Electronic connectors	10	1.56%
3651	Household audio and video equipment	34	5.32%
3825	Instruments to measure electricity	21	3.29%
3829	Measuring and controlling devices	27	4.23%
3357	Nonferrous wiredrawing and insulating	25	3.91%
3579	Office machines	11	1.72%
3672	Printed circuit boards	40	6.26%
3823	Process control instruments	36	5.63%
3663	Radio and Television communications equipment	93	14.55%
3674	Semiconductors and related devices	142	22.22%
3661	Telephone and telegraph apparatus	18	2.82%
	Total ICT manufacturing companies, MANUF	639	50.55%
Code	ICT SERVICE Sector	Number of companies	% over total SERVICE
4841	Cable and other pay Television services	15	2.40%
4899	Communication services	51	8.16%
7373	Computer integrated systems design	126	20.16%
7371	Computer programming services	8	1.28%
5045	Computers, peripherals and software (wholesale)	24	3.84%
7374	Data processing and transmission	43	6.88%
7372	Prepacked software	245	39.20%
4832	Radio broadcasting stations	9	1.44%
4812	Telephone and radio communications	33	5.28%
4813	Telephone communications, except radio	29	4.64%
4833	Television broadcasting stations	42	6.72%
	Total ICT service companies, SERVICE	625	49.45%
	Total	1,264	100.00%

Source: Own elaboration.

Methodology

The model used for the data analysis is a linear regression model defined by the following equation:

$$R\&D_{2018i} = \beta_0 + \beta_1 CF_i + \beta_2 LT_LEV_i + \beta_3 ROA_i + \beta_4 Tr_Credit_i + \beta_5 Size_i + \beta_6 Q_i + \beta_7 I/K_i + \beta_8 R\&D_{2016i} + \beta_9 R\&D_{2017i} + \beta_{10} GDP_GRTH_i + \beta_{11} FDI_Inflow_i + \beta_{12} BERD_i + u_i, i = 1, \dots, 1.264,$$

where $R\&D_{2018}$ is the dependent variable and the rest of the variables -*CF*, *LT_LEV,…,BERD*- are independent. β_0 is the ordinate at origin; the rest of the coefficients β_i relate the effect of the changes of each explanatory variable on the dependent variable; u is the error and *i* includes the observations that correspond to the financial records of 1,264 companies. All explanatory variables correspond to the observations of 2018, with the exception of the variables $R\&D_{2016}$ (2016) y $R\&D_{2017}$ (2017).

One of the basic assumptions of the linear regression model is that the disturbances are spherical, i.e., homoscedastic, $V(u_i) = \sigma^2 \, \forall i$ and uncorrelated $Cov(u_i, u_j) = 0 \, \forall_{i,j,} \, i \neq j$. However, when working with cross-sectional data, the presence of heteroscedasticity is expected and the ordinary least squares estimator is inefficient. The heteroscedasticity tests performed to detect the presence of heteroscedasticity (Breusch-Pagan and White contrasts), as well as the inspection of the residual plots, confirm the hypothesis that the variance of the error term is not constant for the whole sample. Therefore, the estimation method used in the analysis is the Generalized Least Squares (GLS) method, which estimator is the minimum variance estimator. Data processing is performed using version 4.1.1 of the free R software.

The following is the exact description of each of the variables used in the model. In this study R&D expenditure is used as a proxy for investment in innovation. RD_{2018} is the dependent variable and is calculated as the ratio of total R&D expenditures of 2018 over the replacement value of the company's assets, *K*.

The independent firm-level variables are as follows. *CF* is cash flow and represents the company's internal funds in 2018. It is measured as earnings before interest, taxes, depreciation and amortization, over *K*. *LT_LEV* is a long-term debt of 2018 and is calculated as the ratio of long-term debt to total

assets. *ROA* represents the profitability of the company in 2018 and is calculated as EBITDA divided by the company's total assets. *Tr_Credit* is a type of short-term debt and is calculated as accounts payable to total assets, as per balance sheet of 2018. *Size* corresponds to the logarithm of total assets registered in 2018. *Q* is Tobin's Q that represents growth opportunities for a company in 2018. It is calculated, following Pindado et al. (2008), as the market value of the firm over *K*. *I/K* reflects the fixed investment made by the company and is calculated as the ratio of investment, *I*, over *K*. RD_{2016} and RD_{2017} represent expenditures in R&D in the previous two years (2016 and 2017) and are calculated as the ratio of total R&D expenditures of each year over *K*.

The independent macroeconomic variables include the following three. *GDP_GRTH* is the country's economic growth rate registered in 2018. It is measured as the change in the logarithm of GDP between period *t* and *t-1*. *FDI_Inflow* represents inward foreign direct investment (FDI) flows in 2018 and is measured as the ratio of FDI to GDP of the host country. *BERD* is business enterprise expenditures in research and development as percentage of GDP registered in 2018. It measures R&D intensity of a country and it is drawn from the OECD's MSTI database. The basic statistics of the sample are shown in Table 3.

Table 3. Descriptive statistics of the variables

Variables	Min	Max	Mean	St. Dev.
CF	-1,4492	0,4944	0,0440	0,1260
LT_LEV	0,0274	0,9983	0,4467	0,2101
ROA	-1,9732	15,6573	0,0967	0,7455
Tr_Credit	0,0000	0,614	0,0690	0,0731
Size	-0,1174	13,4184	5,8529	2,1543
Q	0,1848	12,7415	1,4589	1,2922
I/K	-1,1963	0,8536	0,1185	0,1705
$R\&D_{2018}$	0,0000	0,4981	0,0303	0,0551
$R\&D_{2017}$	0,0000	0,4831	0,2962	0,0530
$R\&D_{2016}$	0,0000	0,4835	0,0303	0,0552
GDP_GRTH	0,2754	5,3490	2,1039	1,2096
FDI_Inflow	-26,1827	5,6096	1,1329	2,7892
BERD	0,0692	4,3609	2,3958	0,9332

Source: Own elaboration.

Results

The results of the global analysis applied to all sampled ICT companies are shown in the model (a) (see Table 4).

Table 4. Results: Global model (a) and model by sector (b)

Variables	Model (a): Global		Model (b): Sector			
			Manufacture		Service	
CF	-0.0266	(-7.0977)***	- 0.0521	(-7.6065)***	-0.0093	(-0.2717)***
LT_LEV	-0.0058	(-1.5766)	-0.0093	(-1.3368)	-0.0033	(-1.0055)
ROA	0.0001	(0.3179)	-0.0003	(0.3766)	0.0001	(0.2140)
Tr_Credit	-0.0003	(-0.0645)	-0.0045	(-0.3864)	0.0051	(0.9652)
Size	0.0007	(3.2562)***	0.0018	(4.2171)***	0.0000	(0.1998)
Q	0.0009	(2.5352)***	0.0019	(2.3977)**	0.0000	(0.2416)
I/K	-0.0108	(-3.9910)***	-0.0168	(-3.4974)***	-0.0040	(-1.5990)
$R\&D_{2016}$	0.2614	(10.1631)***	0.2988	(7.2951)***	0.2187	(8.1140)***
$R\&D_{2017}$	0.7069	(26.4274)***	0.5980	(13.7795)***	0.8134	(29.7099)***
GDP_GRTH	0.0011	(2.8518)***	0.0021	(3.0044)***	0.0004	(1.2399)
FDI_Inflow	0.0000	(0.4872)	0.0000	(0.3640)	0.0001	(0.6462)
BERD	-0.0002	(-0.4305)	-0.0010	(-1.1362)	-0.0001	(-0.2246)
Constant	-0.0029	(-1.3601)	-0.0058	(-1.4251)	-0.0003	(-0.1550)

Note: significance levels at *10%; **5%; ***1%.
Source: Own elaboration.

Liquidity, expressed through cash flow (*CF*), is of great importance for any company. However, related to innovation, it is not a proper funding source, as suggested by Alkhataybeh (2021). This is because *CF* has a negative associated coefficient and is significant at 99%. So, higher cash flow in ICT companies reduce R&D investment, what corresponds to the results shown in previous research (Kim et al., 1998; Almeida et al., 2004). It looks like cash flow is not primarily allocated for R&D needs, but to other ones that a technological company considers to be a priority.

The firm's size (*Size*), shown as significant and with a positive associated coefficient, is a relevant factor that influences positively the decision to invest in R&D. This result is consistent with the traditional approach that relates the company size directly to the effort it applies in terms of innovation (Kathuria, 2008; Zona et al., 2013). Growth opportunities of tech companies, expressed through Tobin's Q, are also critical for R&D: they generate a positive effect on it since the associated coefficient to *Q* is positive and significant. It is consistent with general findings of the previous studies (Youndt et al., 2004; Guariglia, 2008). Another determinant of investment in innovation is the

investments the ICT companies make in fixed assets (*I/K*). The associated coefficient of *I/K* is significant and has a negative sign suggesting that fixed and R&D investments do not occur simultaneously. This result goes in line with the idea of Filatotchev and Piesse (2009), who predicted an overall negative effect of fixed investment on R&D.

Another important firm-level factor that impacts corporate R&D decisions is the prior effort that the company made in innovation. The associated coefficient of the variables $R\&D_{2016}$ and $R\&D_{2017}$ are positive and significant at 99%. This means that they drive increased R&D investment in the current year. The rest of the firm-level variables, such as *ROA* and *Tr_Credit*, apparently, do not determine corporate R&D investment. It means that it is not clear that profitability and trade credit may serve to finance innovation in ICT companies.

Among the macro variables used for this analysis it is only one – *GDP_GRTH*– that generates significant impact on corporate R&D. That is, the influence of the economic growth of a country is found to be positive for all ICT companies. So, in growing economies we can expect larger R&D investments made by technological companies. This result corresponds to the previous studies (Lam & Shiu, 2010; Schmookler, 2013; Sawng et al., 2021) that stress that this effect may be due to higher expectations of companies to obtain governmental support to R&D or to improve their economic results taking advantage of the favorable environment that would help finance innovation activities. Finally, the other two macroeconomic variables – *FDI_Inflow* and *BERD*– are not significant. This means that, generally speaking, the corporate decision of ICT companies to invest in R&D does not depend on the inflow capitals of FDI and the business sector's spending on R&D, BERD.

The second model (b), is constructed by dividing the companies into two large sectors –ICT manufacturing and ICT service firms–, on the basis of SIC classification, as explained previously in the distribution of the sample (see Table 4).

ICT manufacturing firms show very similar results as in the model (a). Larger cash flow and fixed investment decrease corporate investment in innovation; the variables, such as size, growth opportunities, previous R&D spending and GDP growth, influence positively R&D activities. Focusing on the ICT service companies, a very different behavior is detected. Their decision to invest in R&D depends exclusively on their liquidity and R&D spending in the previous two years. As in the main model, cash flow looks inappropriate to finance innovation-based projects in these companies, while

previous R&D efforts have a positive impact on R&D investment in the current year. Finally, it is worth noting that for the ICT service companies fixed investment (*I/K*) has a negative associated coefficient and it is very close to be significant. Nevertheless, there is not enough evidence to say that fixed investment is critical for innovation in this group of firms.

Additionally, we analyze alternative groups of ICT companies classified according to the following three criteria: (1) growth opportunities, expressed though Tobin's Q as a firm-level variable, (2) gross domestic product spending on R&D, as a macroeconomic variable, and (3) region in which the company is situated. Each of the aforementioned models include two groups of companies to which the main equation is applied. The purpose is to check for the robustness of our results and for eventual differences with respect to the main pattern obtained through the first model (a). More specifically, we would like to determine the behavior of ICT companies located in Europe and compare it with the rest of the regions included in the sample.

The model (c) includes the ICT companies with low growth opportunities (traditionally, with Q below 1) and those with high opportunities (Q over 1). The results of the estimation obtained in this model are indicated in Table 5.

Table 5. Results: Model by growth opportunities (c)

Variables	Model (c): Growth Opportunities			
	Q<1		Q≥1	
CF	-0.0170	(-2.2924)**	-0.0286	(-5.8520)***
LT_LEV	-0.0093	(-2.0712)**	-0.0061	(-1.0778)
ROA	-0.0003	(-0.2750)	-0.0002	(-0.3835)
Tr_Credit	-0.0055	(-0.8566)	0.0041	(0.3987)
Size	0.0003	(1.1957)	0.0010	(2.7193)***
Q	0.0045	(1.6547)*	0.0005	(1.0519)
I/K	-0.0017	(-0.6434)	-0.0200	(-4.1935)***
$R\&D_{2016}$	0.2786	(6.6366)***	0.2594	(7.6287)***
$R\&D_{2017}$	0.6486	(14.7227)***	0.7158	(20.2649)***
GDP_GRTH	0.0006	(1.5595)	0.0011	(1.6905)*
FDI_Inflow	0.0002	(1.5554)	-0.0000	(-0.0279)
BERD	-0.0002	(-0.4377)	0.0000	(0.0675)
Constant	-0.0026	(-0.9443)	-0.0033	(-0.9442)

Note: significance levels at *10%; **5%; ***1%.
Source: Own elaboration.

There are certain differences observed between the two groups of companies. On the one hand, companies with low growth opportunities show a higher dependence on their cash flow, long-term debt, opportunities to grow and previous investment in R&D. More specifically, the influence of cash flow

(*CF*) and long-term leverage (*LT_LEV*) is negative. This refers back to the previous findings that say that ICT companies with higher cash flow and leverage invest less in R&D (Simerly and Li, 2000; Almeida et al., 2004; Singh and Faircloth, 2005). The influence of growth opportunities and the effort applied in innovation in the previous two years is positive since the three variables – *Q*, $R\&D_{2016}$ and $R\&D_{2017}$ – show a significant and positive associated coefficient. The rest of the variables are not significant, so they generate no influence on the corporate decision of the ICT companies with low business opportunities to invest in R&D.

Model (d) includes two groups of companies: one located in the countries which contribution to R&D as a percentage of the total GDP is below 3% and another one with contribution to R&D over 3%. The threshold of 3% corresponds to the target defined within the Europe 2020 plan to be achieved by the countries in terms of gross domestic spending on R&D. The results of the estimation applied to model (d) are shown in Table 6.

Table 6. Results: Model by GDP spending on R&D (d)

Variables	Model (d): GDP spending on R&D			
	RD_GDP<3%		RD_GDP<3%	
CF	-0.0317	(-5.6813)***	-0.0140	(-2.7342)***
LT_LEV	-0.0090	(-1.5277)	-0.0036	(-0.7468)
ROA	-0.0002	(-0.3159)	-0.0000	(-0.0170)
Tr_Credit	0.0025	(0.2428)	-0.0005	(-0.0865)
Size	0.0009	(2.3482)**	0.0000	(0.0683)
Q	0.0013	(2.3592)**	-0.0003	(-0.8007)
I/K	-0.0193	(-4.2033)***	-0.0048	(-1.5505)
$R\&D_{2016}$	0.2390	(5.9986)***	0.2728	(8.3890)***
$R\&D_{2017}$	0.7320	(17.4328)***	0.6497	(19.9096)***
GDP_GRTH	-0.0000	(-0.1076)	0.0006	(0.9425)
FDI_Inflow	-0.0000	(-0.3737)	0.0007	(2.4550)**
BERD	0.0015	(0.9242)	0.0007	(0.6085)
Constant	-0.0018	(-0.4774)	-0.0010	(-0.2970)

Note: significance levels at *10%; **5%; ***1%.
Source: Own elaboration.

Those ICT companies located in countries with weaker contribution to innovation show strong dependence on cash flow, size, growth opportunities, fixed investment and previous investment in R&D. Cash flow (*CF*) and fixed investment (*I/K*) impact negatively on the corporate R&D investment. This follows the pattern detected in our previous models. Finally, a company's size (*Size*), growth opportunities (*Q*) and previous spending on R&D ($R\&D_{2016}$ and

R&D$_{2017}$) positively influence the current R&D investment. These results are similar to those shown in the rest of the models.

Regarding the second group in model (d), which includes the companies located in the countries with higher contribution to innovation, over 3% of their GDP, the significant results are shown only for the variables of cash flow, previous spending on R&D and FDI inflows. As in all previous models, cash flow (*CF*) is shown significant and with negative associated coefficients. So, ICT companies invest less in R&D when they have higher cash flow. R&D expenditure in 2016 and 2017 is significant and has a positive sign. This means that tech companies increase their investment in innovation when they invested in R&D in the previous two years. The sensitivity the companies show to incoming foreign capitals (*FDI_inflow*), as macroeconomic factor, is new in this study. This variable is significant and has a positive associated coefficient, so it drives increased investment in R&D of ICT companies located in countries that highly support innovation.

The results for the third additional model (e), which includes companies located in Europe and in the rest of the regions, are summarized in Table 7. This comparison between the two blocks of countries allows us to determine the particularities of the R&D investment behavior of European ICT companies as well as companies of other regions, such as North America (United States and Canada), Central America (Mexico), Asia (Japan, Korea), the Pacific (Australia and New Zealand) and the Middle East (Israel).

Table 7. Results: Model by regional distribution (e)

Variables	Model (e): regions			
	Europe		Other regions	
CF	-0.0907	(-5.8692)***	-0.0271	(-4.8933)***
LT_LEV	-0.0041	(-0.6473)	-0.0059	(-1.3125)
ROA	0.0801	(4.4035)***	-0.0002	(-0.4350)
Tr_Credit	0.0038	(0.4056)	-0.0041	(-0.5360)
Size	0.0002	(0.7814)	0.0007	(2.2945)**
Q	0.0008	(1.5729)	0.0008	(1.7362)*
Fix_Inv	-0.0107	(-2.6143)***	-0.0131	(-3.7533)***
R&D $_{2016}$	0.2257	(4.7138)***	0.2659	(8.7876)***
R&D $_{2017}$	0.7410	(14.7677)***	0.6958	(22.1200)***
GDP_GRTH	-0.0006	(-1.0012)	0.0016	(3.0198)***
FDI_Inflow	-0.0000	(-0.2559)	0.0002	(0.5995)
BERD	-0.0009	(-0.6313)	-0.0003	(-0.5023)
Constant	0.0054	(1.2839)	-0.0028	(-0.9331)

Note: significance levels at *10%; **5%; ***1%.
Source: Own elaboration.

As in our previous models, cash flow (*CF*) negatively impacts on the decisions of European ICT companies to invest in R&D. Once again, this shows that cash flow is not an appropriate funding source for innovation. Nevertheless, profitability (*ROA*), associated with firm's capacity to generate internal funds through profits, appears to be an important element of corporate finance that ICT companies situated in Europe allocate for financing of their R&D-based projects. It is shown as significant at 99% with a positive associated coefficient. This is quite a new and even unexpected result since it was not shown in the rest of the models. It corresponds to the findings obtained in other studies, for example, by Roucan-Kane et al. (2007). According to Rocca et al. (2011), high earnings may be a substitute for debt, so it may be the case that profitability is used to decrease the risk associated to R&D investment and boost it.

Growth opportunities (*Q*), with a positive sign and very close to being significant, look like they are positively influencing investment in innovation of European ICT firms. However, these evidences are not strong enough to say that growth opportunities do generate a positive impact on R&D investment. Fixed investment (*I/K*), as in many other models, is significant and has a negative associated coefficient. So, it negatively influences R&D activities of European ICT firms. In other words, if a company increases investment in fixed assets, it diminishes its R&D intensity in the current year. Finally, the effort applied to innovation in the previous two years is absolutely fundamental to ensure a strong investment in R&D, since the variables $R\&D_{2016}$ and $R\&D_{2017}$ are significant and have a positive associated coefficient.

The results obtained for the group of companies located in the rest of the regions allow us to observe certain similarities, but also differences in comparison to Europe. The similarities refer to the fact that high levels of liquidity (*CF*) and investments in fixed assets (*I/K*) decrease R&D activities, while higher spending on innovation in the previous two years ($R\&D_{2016}$ and $R\&D_{2017}$) increases the intensity of R&D investment. The differences are observed with regard to the firm's size (*Size*), growth opportunities (*Q*) and the economic growth of the country (*GDP_GRTH*). These three factors positively influence the decision of ICT companies in non-European regions to invest in R&D. These results correspond to the previous findings of this study.

Conclusion

Digitalization is challenging for any organization and nation in a modern economy. This is also true for ICT companies that must ensure the effectiveness of technological solutions applied by the rest of industries. This will be hard to achieve or even impossible if tech firms neglect their internal processes and activities related to innovation. Investment in innovation, often referred to as R&D expenditure, is long-term, involves high related costs, much uncertainty and generates low collateral value. In addition, it compromises the company's short-term economic results and liquidity, which increases a company's risk. For ICT companies, investment in R&D is a significant part of all their investments. That is why it is important to determine what influences the decisions of the ICT companies to undertake innovation-based projects. In an attempt to try to find an answer, we made a literature review and carried out an empirical analysis focusing on a number of factors that favor or hamper corporate R&D investment made by technological companies worldwide.

Our sample comprises 1,264 ICT companies from 22 countries with complete data for the period from 2016 to 2018. These companies are classified by SIC code into two large sectors: ICT manufacturing (639) and ICT service companies (625). The data are taken from the S&P Capital IQ database, the World Bank's World Development Indicators database, the OECD's MSTI and the International Monetary Fund. The analysis uses a univariate model estimated by generalized least squares (GLS). It helps test, in a conjoint way, the influence of different independent firm- and country-level variables on R&D investment made by the ICT companies.

The findings of the empirical analysis show interesting facts and help understand what influences the decision of the technological companies to invest in innovation. With regard to the firm-level factors, the following variables are analyzed: cash flow, long-term debt, profitability, trade credit, firm's size, growth opportunities, investment in fixed assets and R&D expenditure made in the previous two years.

Cash flow is considered to be one of the most critical factors that influences negatively R&D investment decisions. As observed in most sectors, when firms have higher cash flow they experience fewer financial constraints, so they can invest more in innovation. However, ICT companies behave differently, allocating their cash flow to other needs or strategies. This pattern is detected in all models.

Regarding the rest of financing options for tech firms, a long-term debt is generally considered as a specific instrument to finance innovation. Nevertheless, the evidences indicate that it is not very clear whether it influences significantly R&D investment. The only exception is found in ICT companies with low growth opportunities, for which a long-term debt is not an appropriate funding source for innovation. Therefore, it can be assumed that technological companies seek funding for their R&D activities from other sources. Another financing option for innovation is profitability, but this is relevant only for European ICT companies. Finally, trade credit has no effect in any model on the decision of ICT firms to invest in R&D.

As for the remaining firm-level variables, the firm's size, as observed in many other studies, has a positive effect on R&D investment decisions. This is probably because large companies already have an infrastructure and experience that makes it easier to manage this type of investment. This finding is replicated among the ICT manufacturing companies, the companies with high growth opportunities and the companies located in the countries with weak spending on innovation (below 3% of GDP) and from non-European regions. Regarding business opportunities, measured through Tobin's Q, it is observed that if these are high, investment in innovation made by ICT firms, in general, increases. The same results are found for companies from the ICT manufacturing sector, with low growth opportunities, located in non-European countries and in the countries with GDP spending on R&D below 3%.

With regard to investments in fixed assets, which are complementary to R&D investments, it is important to note that they do not occur in the same year, since the relationship shown in the analysis is negative. This finding is also significant for the ICT manufacturing companies and the companies with high business opportunities, located in non-European countries and in the countries with weak contribution for innovation. Finally, R&D expenditure in the previous two years favors R&D investment in the current year. This result is replicated in all the models analyzed in this study.

Regarding the macroeconomic factors, this research includes the following three: the country's economic growth rate, FDI inflows and the business private sector spending on R&D, BERD.

On the one hand, the country's economic growth, considered as a benchmark of the investment climate, favors greater investment in R&D by the ICT companies. This result is also observed among companies from the ICT manufacturing sector, with high growth opportunities and located in non-European countries. On the other hand, the ability to attract foreign capital is one of the factors that helps create a stable economic climate that favors

investments in innovation of the private sector, in this case, of the technological one. The results obtained indicate that corporate investment in innovation increases only among ICT companies located in the countries with high spending on R&D when there is a greater inflow of FDI. Finally, the effect of the private business sector's expenditure on R&D has no effect on the decision of the ICT companies to invest in innovation.

The analysis carried out in this study provides a better understanding of the investment behavior of ICT companies worldwide. The findings can be used to design and develop policies, establish measures and facilitate mechanisms for optimal management of R&D investment by companies from the technological sector of many countries. Finally, the authors notice that using R&D expenditure as a proxy for investment in innovation is limiting since it reflects only partially the strategy applied in a company. In this sense, it will be relevant, in future studies, to consider some other data, like purchases aimed at intensifying corporate R&D activities or patents registered by the companies or within the sector.

References

Agosin, M. R. & Machado, R. (2007). Openness and the international allocation of foreign direct investment. *The Journal of Development Studies*, 43(7), 1234-1247.

Aivazian, V. A., Ge, Y., & Qiu, J. (2005). The impact of leverage on firm investment: Canadian evidence. *Journal of corporate finance*, *11*(1-2), 277-291.

Alfaro, L., Chanda, A., Kalemli-Ozcan, S. & Sayek, S. (2004). FDI and economic growth: the role of local financial markets. *Journal of international economics*, 64(1), 89-112.

Ali-Yrkkö, J. (2004). *Impact of public R&D financing on private R&D: Does financial constraint matter?* (No. 943). Research Institute of the Finnish Economy (ETLA).

Al-Kahtani, N., & Al-Eraij, M. (2018). Does capital structure matter? Reflection on capital structure irrelevance theory: Modigliani-Miller theorem (MM 1958). *International Journal of Financial Services Management, 9*(1), 39-46.

Alkhataybeh, A. (2021). Working capital and R&D smoothing: evidence from the Tel Aviv stock exchange. *Journal of Applied Economics, 24*(1), 91-102.

Almeida, H., Campello, M., & Weisbach, M. S. (2004). The cash flow sensitivity of cash. *The journal of finance, 59*(4), 1777-1804.

Almeida, H., Campello, M., & Weisbach, M. S. (2011). Corporate financial and investment policies when future financing is not frictionless. *Journal of Corporate Finance, 17*(3), 675-693.

Anderson, C. W., & Garcia-Feijóo, L. (2006). Empirical evidence on capital investment, growth options, and security returns. *The Journal of Finance, 61*(1), 171-194.

Aoun, D., & Hwang, J. (2008). The effects of cash flow and size on the investment decisions of ICT firms: A dynamic approach. *Information economics and policy*, *20*(2), 120-134.

Arikawa, Y., Kawanishi, T., & Miyajima, H. (2011). Debt, ownership structure, and R&D investment: Evidence from Japan. In *RIETI Discussion Paper Series*, *11-E-013*.

Arnold, G. (2008). *Corporate financial management*. Pearson Education.

Baldi, G., & Bodmer, A. (2018). R&D investments and corporate cash holdings. *Economics of Innovation and New Technology*, *27*(7), 594-610.

Bardhan, I., Krishnan, V., & Lin, S. (2013). Research note—business value of information technology: testing the interaction effect of IT and R&D on Tobin's Q. *Information Systems Research*, *24*(4), 1147-1161.

Baum, C. F., Caglayan, M., & Talavera, O. (2013). The effects of future capital investment and R & D expenditures on firms' liquidity. *Review of International Economics*, *21*(3), 459-474.

Baussola, M. (2000). The causality between R&D and investment. *Economics of Innovation and New Technology*, *9*(4), 385-399.

Bebczuk, R. N. (2002). R&D expenditures and the role of government around the World. *Estudios de economia*, [*Economics Studies*], *29*(1), 109-121.

Becker, B. (2013). The determinants of R&D investment: a survey of the empirical research. *Loughborough Universtiy Economics Discussion Paper Series*, *9*.

Beil, R. O., Ford, G. S., & Jackson, J. D. (2005). On the relationship between telecommunications investment and economic growth in the United States. *International Economic Journal*, *19*(1), 3-9.

Beladi, H., Deng, J., & Hu, M. (2021). Cash flow uncertainty, financial constraints and R&D investment. *International Review of Financial Analysis*, *76*, 101785.

Benito, A. (2003). The capital structure decisions of firms: is there a pecking order? *Documentos de trabajo/Banco de España*, [*Working documents/Bank of Spain*], *0310*.

Bhagat, S., & Welch, I. (1995). Corporate research & development investments international comparisons. *Journal of Accounting and Economics*, *19*(2-3), 443-470.

Bhattacharya, M., & Bloch, H. (2004). Determinants of innovation. *Small business economics*, *22*(2), 155-162.

Biais, B., & Gollier, C. (1997). Trade credit and credit rationing. *The review of financial studies*, *10*(4), 903-937.

Bloch, C. (2005). R&D investment and internal finance: The cash flow effect. *Economics of Innovation and New Technology*, *14*(3), 213-223.

Blomström, M., Lipsey, R. E., & Zejan, M. (1996). Is fixed investment the key to economic growth? *The Quarterly Journal of Economics*, *111*(1), 269-276.

Bloom, N. (2007). Uncertainty and the Dynamics of R&D. *American Economic Review*, *97*(2), 250-255.

Bolton, P., Chen, H., & Wang, N. (2011). A unified theory of Tobin's q, corporate investment, financing, and risk management. *The journal of Finance*, *66*(5), 1545-1578.

Bond, S., Harhoff, D., & Van Reenen, J. (2005). Investment, R&D and financial constraints in Britain and Germany. *Annales d'Economie et de Statistique*, [*Annals of Economics and Statistics*], 433-460.

Boot, A. W. (2000). Relationship banking: what do we know? *Journal of Financial Intermediation* 0(1): 7-25.

Borensztein, E., De Gregorio, J. & Lee, J. W. (1998). How does foreign direct investment affect economic growth? *Journal of international Economics*, 45(1), 115-135.

Brown, J. R., Martinsson, G., & Petersen, B. C. (2012). Do financing constraints matter for R&D? *European Economic Review*, *56*(8), 1512-1529.

Brown, J. R., Fazzari, S. M., & Petersen, B. C. (2009). Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom. *The Journal of Finance*, *64*(1), 151-185.

Brown, J. R., & Petersen, B. C. (2011). Cash holdings and R&D smoothing. *Journal of Corporate Finance*, *17*(3), 694-709.

Brown, J. R., & Petersen, B. C. (2015). Which investments do firms protect? Liquidity management and real adjustments when access to finance falls sharply. *Journal of Financial Intermediation*, *24*(4), 441-465.

Bryan, A., Ko, J., Hu, S. J., & Koren, Y. (2007). Co-evolution of product families and assembly systems. *CIRP annals*, *56*(1), 41-44.

Busom, I. (2012). Tax incentives or subsidies for R&D? *UNU-Merit working paper*, *56*.

Cao, Y., & Zhao, L. (2011). Intellectual property management model in enterprises: a technology life cycle perspective. *International Journal of Innovation and Technology Management*, *8*(02), 253-272.

Carbo-Valverde, S., Rodriguez-Fernandez, F., & Udell, G. F. (2016). Trade credit, the financial crisis, and SME access to finance. *Journal of Money, Credit and Banking*, *48*(1), 113-143.

Carboni, O. A., & Medda, G. (2019). Does R&D spending boost tangible investment? An analysis on European firms. *Applied Economics*, *51*(28), 3049-3065.

Carpenter, R. E., & Petersen, B. C. (2002). Capital market imperfections, high-tech investment, and new equity financing. *The Economic Journal*, *112*(477), F54-F72.

Carroll, C. D., & Weil, D. N. (1994, June). Saving and growth: a reinterpretation. In *Carnegie-Rochester conference series on public policy* (Vol. 40, pp. 133-192). North-Holland.

Chen, W. R., & Miller, K. D. (2007). Situational and institutional determinants of firms' R&D search intensity. *Strategic management journal*, *28*(4), 369-381.

Cheng, N. S., & Pike, R. (2003). The trade credit decision: evidence of UK firms. *Managerial and decision Economics*, *24*(6-7), 419-438.

Chiao, C. (2002). Relationship between debt, R&D and physical investment, evidence from US firm-level data. *Applied financial economics*, *12*(2), 105-121.

Chinloy, P., Jiang, C., & John, K. (2020). Investment, depreciation and obsolescence of R&D. *Journal of Financial Stability*, *49*, 100757.

Choi, Y. R., Zahra, S. A., Yoshikawa, T., & Han, B. H. (2015). Family ownership and R&D investment: The role of growth opportunities and business group membership. *Journal of Business Research*, *68*(5), 1053-1061.

Choong, C. K. & Lam, S. Y. (2011). Foreign direct investment, financial development and economic growth: Panel data analysis. *IUP Journal of Applied Economics*, 10(2), 57

Coad, A., & Rao, R. (2010). Firm growth and R&D expenditure. *Economics of Innovation and New Technology*, *19*(2), 127-145.

Coad, A., Pellegrino, G., & Savona, M. (2016). Barriers to innovation and firm productivity. *Economics of Innovation and New Technology*, *25*(3), 321-334.

Coccia, M. (2015). Technological paradigms and trajectories as determinants of the R&D corporate change in drug discovery industry. *International Journal of Knowledge and Learning*, *10*(1), 29-43.

Czarnitzki, D. (2006). Research and development in small and medium-sized enterprises: The role of financial constraints and public funding. *Scottish journal of political economy*, *53*(3), 335-357.

Czarnitzki, D., & Hottenrott, H. (2011). R&D investment and financing constraints of small and medium-sized firms. *Small business economics*, *36*(1), 65-83.

Damanpour, F. (2010). An integration of research findings of effects of firm size and market competition on product and process innovations. *British Journal of Management*, *21*(4), 996-1010.

Danielson, M. G., & Scott, J. A. (2004). Bank loan availability and trade credit demand. *Financial Review*, *39*(4), 579-600.

David, P., O'Brien, J. P., & Yoshikawa, T. (2008). The implications of debt heterogeneity for R&D investment and firm performance. *Academy of Management Journal*, *51*(1), 165-181.

Dedehayir, O., & Steinert, M. (2016). The hype cycle model: A review and future directions. *Technological Forecasting and Social Change*, *108*, 28-41.

Deng, Y. (2008). The value of knowledge spillovers in the US semiconductor industry. *International Journal of Industrial Organization, 26(4)*, 1044-1058

Driver, C., & Guedes, M. J. C. (2012). Research and development, cash flow, agency and governance: UK large companies. *Research Policy*, *41*(9), 1565-1577.

Evangelista, R. (2000). Sectoral patterns of technological change in services. *Economics of Innovation and New Technologies*, 9, 183-221.

Fama, E. F. & French, K. R. (2002). Testing trade-off and pecking order predictions about dividends and debt. *Review of Financial Studies, 15*(1), 1-33.

Fazzari, S., Ferri, P., & Greenberg, E. (2008). Cash flow, investment, and Keynes–Minsky cycles. *Journal of Economic Behavior & Organization*, *65*(3-4), 555-572.

Filatotchev, I., & Piesse, J. (2009). R&D, internationalization and growth of newly listed firms: European evidence. *Journal of International Business Studies*, *40*(8), 1260-1276.

Fischer, S. (1993). The role of macroeconomic factors in growth. *Journal of monetary economics, 32(3)*, 485-512.

Fisman, R., & Love, I. (2003). Trade credit, financial intermediary development, and industry growth. *The Journal of finance*, *58*(1), 353-374.

Frank, M. Z., & Goyal, V. K. (2009). Capital structure decisions: which factors are reliably important? *Financial management*, *38*(1), 1-37.

Frascati, M. (2002). *Proposed standard practice for surveys on research and experimental development*. Paris: OCDE.

Gallouj, F. y Weinstein, O. (1997). Innovation in services. *Research Policy*, 26, 537-556.

García-Quevedo, J., Pellegrino, G., & Savona, M. (2017). Reviving demand-pull perspectives: The effect of demand uncertainty and stagnancy on R&D strategy. *Cambridge Journal of Economics*, *41*(4), 1087-1122.

Guariglia, A. (2008). Internal financial constraints, external financial constraints, and investment choice: Evidence from a panel of UK firms. *Journal of banking & finance*, *32*(9), 1795-1809.

Guariglia, A., & Mateut, S. (2006). Credit channel, trade credit channel, and inventory investment: Evidence from a panel of UK firms. *Journal of Banking & Finance*, *30*(10), 2835-2856.

Guellec, D., & Van Pottelsberghe De La Potterie, B. (2003). The impact of public R&D expenditure on business R&D. *Economics of innovation and new technology*, *12*(3), 225-243.

Guerrieri, P. & Meliciani, V. (2005). Technology and international competitiveness: the interdependence between manufacturing and producer services. *Structural Change and Economic Dynamics*, 16, 489-502.

Hall, B. H., & Lerner, J. (2009). *The financing of R&D and Innovation*. *Handbook of the Economics of Innovation.* Elsevier-North.

Harris, R., & Trainor, M. (2009). *Why do some firms undertake R&D whereas others do not?* Discussion Papers; SERC (Spatial Economics Research Centre): London, UK.

Hart, O. D., & Moore, J. (1994). Debt and seniority: An analysis of the role of hard claims in constraining management. *American Economic Review,* 85(3), 567-585.

Hill, P. (1999). Tangibles, intangibles and services: a new taxonomy for the classification of output. *The Canadian Journal of Economics*, 32 (2), 426-446.

Hitt, M. A., Hoskisson, R. E., Ireland, R. D., & Harrison, J. S. (1991). Effects of acquisitions on R&D inputs and outputs. *Academy of Management journal*, *34*(3), 693-706.

Hipp, C. & Grupp, H. (2005). Innovation in the service sector: The demand for service-specific innovation measurement concepts and typologies. *Research Policy*, 34(4), 517-535.

Honjo, Y., & Harada, N. (2006). SME policy, financial structure and firm growth: Evidence from Japan. *Small Business Economics*, *27*(4), 289-300.

Hölzl, W., Janger, J., Reinstaller, A., Stadler, I., Unterlass, F., Daimer, S., & Stehnken, T. (2010). Barriers to Internationalisation and Growth of EU's Innovative Companies. PRO INNO Europe: INNO-Grips II Report. *WIFO Studies.*

Hunady, J., Pisar, P., & Durcekova, I. (2020). R&D investments in the European ICT sector: implications for business performance. *Business Systems Research: International journal of the Society for Advancing Innovation and Research in Economy*, *11*(3), 30-44.

Jensen, M. C. (1986). Agency costs of free cash flow, corporate finance, and takeovers. *The American economic review*, *76*(2), 323-329.

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of financial economics*, *3*(4), 305-360.

Kathuria, V. (2008). The impact of FDI inflows on R&D investment by medium-and high-tech firms in India in the post-reform period. *Transnational Corporations*, *17*(2), 45.

Khan, M., & Luintel, K. B. (2006). Sources of Knowledge and Productivity: How robust is the Relationship? *STI Working Paper 2006/6.* OECD, Paris.

Kim, C. S., Mauer, D. C., & Sherman, A. E. (1998). The determinants of corporate liquidity: Theory and evidence. *Journal of financial and quantitative analysis*, *33*(3), 335-359.

Koutroumpis, P., Leiponen, A., & Thomas, L. D. (2017). *The young, the old and the innovative: The impact of R&D on firm performance in ICT versus other sectors* (No. 51). ETLA Working Papers.

Koutroumpis, P., Leiponen, A., & Thomas, L. D. (2020). Small is big in ICT: The impact of R&D on productivity. *Telecommunications Policy*, *44*(1), 101833.

Kravchenko, O., Leshchenko, M., Marushchak, D., Vdovychenko, Y., & Boguslavska, S. (2019). The digitalization as a global trend and growth factor of the modern economy. In *SHS Web of Conferences* (Vol. 65, p. 07004). EDP Sciences.

Kumar, P., & Li, D. (2016). Capital investment, innovative capacity, and stock returns. *The Journal of Finance*, *71*(5), 2059-2094.

La Rocca, M., La Rocca, T., & Cariola, A. (2011). Capital structure decisions during a firm's life cycle. *Small Business Economics*, *37*(1), 107-130.

Laborda, J., Salas-Fumás, V., & Suárez, C. (2020). An Endogenous Approach to the Cyclicality of R&D Investment under Credit Constraints: Firms' Cash Flow Matters! *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(2), 33.

Lam, P. L., & Shiu, A. (2010). Economic growth, telecommunications development and productivity growth of the telecommunications sector: Evidence around the world. *Telecommunications Policy*, *34*(4), 185-199.

Lee, P. M., & O'neill, H. M. (2003). Ownership structures and R&D investments of US and Japanese firms: Agency and stewardship perspectives. *Academy of management Journal*, *46*(2), 212-225.

Lewellen, J., & Lewellen, K. (2016). Investment and cash flow: New evidence. *Journal of Financial and Quantitative Analysis*, *51*(4), 1135-1164.

Love, I. (2003). Financial development and financing constraints: International evidence from the structural investment model. *The Review of Financial Studies, 16*, 765-791.

Love, I., Preve, L. A., & Sarria-Allende, V. (2007). Trade credit and bank credit: Evidence from recent financial crises. *Journal of Financial Economics*, *83*(2), 453-469.

Mairesse, J., & Mohnen, P. (2004). The importance of R&D for innovation: a reassessment using French survey data. *The Journal of Technology Transfer, 30*(1), 183-197.

Makki, S. S. & Somwaru, A. (2004). Impact of foreign direct investment and trade on economic growth: Evidence from developing countries. *American Journal of Agricultural Economics*, 86(3), 795-801.

Manganelli, A. G. (2010). *The R&D of Norwegian Firms: an Empirical Analysis*. CREAM Publication No. 5 – 2010, CREAM, BI Norwegian Business School.

Marinković, S., Nikolić, I., & Rakićević, J. (2018). Selecting location for a new business unit in ICT industry. *Zbornik Radova Ekonomski Fakultet u Rijeka*, [*Proceedings of the Faculty of Economics in Rijeka*], *36*(2), 801-825.

Mikkelson, W. H., & Partch, M. M. (2003). Do persistent large cash reserves hinder performance? *Journal of financial and quantitative analysis*, *38*(2), 275-294.

Miles, I. (2005). Innovation in services. In Fagerberg, J., Mowery, D. y Nelson, R. (Eds.), *The Oxford Handbook of Innovation*, Oxford: Oxford University Press.

Miozzo, M. & Soete, L. (2001). Internationalization of services: a technological perspective. *Technological Forecasting and Social Change*, 67, 159-185.

Mišun, J. & Tomšík, V. (2002). Foreign direct investment in Central Europe - Does it crowd in domestic investment? *Prague Economic Papers* no 1.

Modigliani, F., & Miller, M. H. (1963). Corporate income taxes and the cost of capital: a correction. *The American economic review*, 53(3), 433-443.

Moreno, A. M., & Casillas, J. C. (2007). High-growth SMEs versus non-high-growth SMEs: a discriminant analysis. *Entrepreneurship and regional development*, *19*(1), 69-88.

Morrissey, O. & Udomkerdmongkol, M. (2012). Governance, private investment and foreign direct investment in developing countries. *World Development*, 40(3), 437-445.

Muhammad, H., Migliori, S., & Consorti, A. (2022). Corporate governance and R&D investment: does firm size matter? *Technology Analysis & Strategic Management*, 1-15.

Mulkay, B., Hall, B. H., & Mairesse, J. (2001). Firm level investment and R&D in France and the United States: A comparison. In *Investing today for the world of tomorrow* (pp. 229-273). Springer, Berlin, Heidelberg.

Myers, S. (1977). Determinants of corporate borrowing. *Journal of Financial Economics*, *5*, 147-175.

Myers, S. C. (1984). The capital structure puzzle. *The Journal of Finance*, *39*, 574-592.

Myers, S. C., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of financial economics*, *13*(2), 187-221.

Nair, M., Pradhan, R. P., & Arvin, M. B. (2020). Endogenous dynamics between R&D, ICT and economic growth: Empirical evidence from the OECD countries. *Technology in Society*, *62*, 101315.

Nilsen, J. H. (2002). Trade credit and the bank lending channel. *Journal of Money, credit and Banking*, 226-253.

OECD (2015). *Frascati Manual 2015*: Guidelines for Collecting and Reporting Data on Research and Experimental Development.

Ogawa, K., Sterken, E., & Tokutsu, I. (2013). The trade credit channel revisited: evidence from micro data of Japanese small firms. *Small Business Economics*, *40*(1), 101-118.

Ono, M. (2001). Determinants of trade credit in the Japanese manufacturing sector. *Journal of the Japanese and International Economies*, *15*(2), 160-177.

Opler, T. C., & Titman, S. (1994). *The debt-equity choice: An analysis of issuing firms*. Available at SSRN 5909.

Ozdagli, A. K. (2012). Financial leverage, corporate investment, and stock returns. *The Review of Financial Studies*, *25*(4), 1033-1069.

Pederzoli, C., Thoma, G., & Torricelli, C. (2013). Modelling credit risk for innovative SMEs: The role of innovation measures. *Journal of financial services research*, *44*(1), 111-129.

Pellegrino, G., & Savona, M. (2017). No money, no honey? Financial versus knowledge and demand constraints on innovation. *Research policy*, *46*(2), 510-521.

Pindado, J., Rodrigues, L., & de la Torre, C. (2008). How do insolvency codes affect a firm's investment? *International Review of Law and Economics*, *28*(4), 227-238.

Plötscher, C., & Rottmann, H. (2002). Investment Behavior and Financing Constraints in German Manufacturing and Construction Firms: A Bivariate Ordered Probit

Estimation. *ifo Studien, Zeitschrift für empirische Wirtschaftsforschung*, [*ifo studies, journal for empirical economic research*], *48*, 383-400.

Postula, M., & Chmielewski, W. (2019). The impact of intangible assets and R&D expenditure on the market capitalization and EBITDA of selected ICT sector enterprises in the European Union. *International Journal of Economics and Finance*, 11(8), 117-128.

Rachinger, M., Rauter, R., Müller, C., Vorraber, W., & Schirgi, E. (2018). Digitalization and its influence on business model innovation. *Journal of Manufacturing Technology Management.*

Rajan, R. G., & Zingales, L. (1995). What do we know about capital structure? Some evidence from international data. *The journal of Finance*, *50*(5), 1421-1460.

Roucan-Kane, M., Ubilava, D., & Xu, P. (2007). *Effects of firm-specific factors on R&D; expenditures of agribusiness companies* (No. 1240-2016-101622). Working paper No. 07-04, Purdue University.

Sawng, Y. W., Kim, P. R., & Park, J. (2021). ICT investment and GDP growth: Causality analysis for the case of Korea. *Telecommunications Policy*, *45*(7), 102157.

Scheutz, C., & Hägg, C. (2006). Property brands, human capital and Tobin's q. *Journal of Human Resource Costing & Accounting*, *10*(1), 4-10.

Schmookler, J. (2013). Invention and economic growth. In *Invention and Economic Growth*. Harvard University Press.

Serrasqueiro, Z., Nunes, P. M., Leitão, J., & Armada, M. (2010). Are there non-linearities between SME growth and its determinants? A quantile approach. *Industrial and Corporate Change*, *19*(4), 1071-1108.

Shen, K. Y., Yan, M. R., & Tzeng, G. H. (2017). Exploring R&D influences on financial performance for business sustainability considering dual profitability objectives. *Sustainability*, *9*(11),1-21.

Shin, M., & Kim, S. (2011). The effects of cash holdings on R&D smoothing of innovative small and medium sized enterprises. *Asian Journal of Technology Innovation*, *19*(2), 169-183.

Simanjuntak, D. G., & Tjandrawinata, R. R. (2011). *Impact of profitability, R&D intensity, and cash flow on R&D expenditure in pharmaceutical companies*. Department of Business Development, Dexa Medica Group, Jakarta, Indonesia.

Simerly, R. L., & Li, M. (2000). Environmental dynamism, capital structure and performance: a theoretical integration and an empirical test. *Strategic management journal*, *21*(1), 31-49.

Singh, M., & Faircloth, S. (2005). The impact of corporate debt on long term investment and firm performance. *Applied Economics*, *37*(8), 875-883.

Succurro, M., & Costanzo, G. D. (2016). Finance and r&d investment: A panel study of italian manufacturing firms. *International Journal of Economics and Finance*, *8*(8), 95-110.

Svensson, R. (2013). Publicly-funded R&D programs and survival of patents. *Applied Economics*, *45*(10), 1343-1358.

Szewczyk, W., Stančík, J., & Christensen, M. A. (2013). *Investigation of ICT Firms' Decisions on R&D Investment* (No. JRC85346). Institute for Prospective and Technological Studies, Joint Research Centre.

Tobin, J. (1969). A general equilibrium approach to monetary theory. *Journal of money, credit and banking*, *1*(1), 15-29.

Usman, M., Shaique, M., Khan, S., Shaikh, R., & Baig, N. (2017). Impact of R&D investment on firm performance and firm value: evidence from developed nations (G-7). *Revista de Gestão, Finanças e Contabilidade*, [*Journal of Management, Finance and Accounting*], *7*(2), 302-321.

Van den Bergh, J. C. (2009). The GDP paradox. *Journal of Economic Psychology*, *30(2)*, 117-135.

Van Vo, L., & Le, H. T. T. (2017). Strategic growth option, uncertainty, and R&D investment. *International Review of Financial Analysis*, *51*, 16-24.

Varsakelis, N. C. (2001). The impact of patent protection, economy openness and national culture on R&D investment: a cross-country empirical investigation. *Research policy*, *30*(7), 1059-1068.

Veugelers, R. (2016). *The European Union's growing innovation divide* (No. 2016/08). Bruegel Policy Contribution.

Wang, E. C. (2010). Determinants of R&D investment: The Extreme-Bounds-Analysis approach applied to 26 OECD countries. *Research Policy*, *39*(1), 103-116.

Whited, T. M. (2006). External finance constraints and the intertemporal pattern of intermittent investment. *Journal of Financial Economics*, *81*(3), 467-502.

Yang, J., Wang, L., Sun, Z., Zhu, F., Guo, Y., & Shen, Y. (2021). Impact of Monetary Policy Uncertainty on R&D Investment Smoothing Behavior of Pharmaceutical Manufacturing Enterprises: Empirical Research Based on a Threshold Regression Model. *International Journal of Environmental Research and Public Health*, *18*(21), 11560.

Youndt, M. A., Subramaniam, M., & Snell, S. A. (2004). Intellectual capital profiles: An examination of investments and returns. *Journal of Management studies*, *41*(2), 335-361.

Yousefi, A. (2015). A Panel Granger causality test of investment in ICT capital and economic growth: Evidence from developed and developing countries. *Economics World*, *3*(5-6), 109-127.

Yuan, S., Musibau, H. O., Genç, S. Y., Shaheen, R., Ameen, A., & Tan, Z. (2021). Digitalization of economy is the key factor behind fourth industrial revolution: How G7 countries are overcoming with the financing issues? *Technological Forecasting and Social Change*, *165*, 120533.

Zona, F., Zattoni, A., & Minichilli, A. (2013). A contingency model of boards of directors and firm innovation: The moderating role of firm size. *British Journal of Management*, *24*(3), 299-315.

Zong, S. (2022, February). Mathematical evaluation model of financing constraints and R&D innovation from the perspective of big data and cloud computing. In *2022 IEEE International Conference on Electrical Engineering, Big Data and Algorithms (EEBDA)* (pp. 315-318). IEEE.

Chapter 4

The Key Role of Digitalization and European Clusters as Innovation Ecosystems, and Their Implication in the Successful International Promotion of the Member Companies in the Strategic Chinese Sectors: Net-Zero and Smart Cities, Smart Ports and Smart Factories

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Abstract

The purpose of this document is to analyse the key innovation capabilities and resources of the enterprises and RTD performers, specially in the fields of smart cities, smart ports and smart factories.

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These key sectors offer relevant business and R&D opportunities for establishing international cooperation between Valencia Region and the Chinese provinces of Guangdong and Hainan.

Smart cities, smart ports and smart factories sectors are intensively supported by R&D and Sustainable Development Policies defined by Europe (in particular in Spain) and China, in order to achieve to be "climate-neutral regions" by 2050 -economies with net-zero greenhouse gas emissions, according to the areas of interest defined in the Horizon Europe Programme (2021-2027), the R&D Programme defined by the European Commission in order to achieve the ambitious EU sustainable objectives by 2030 and which support the development of European cooperation projects in order to foster innovative solutions, technologies for next generation of cities, ports and industry. Through this document we analyze the current European policies in that fields, and we compare our objectives with the Chinese strategy for smart cities, factories and ports.

As a result we include a capability map for smart cities, factories and ports, after the analysis of 17 companies of the cluster of energy in the Valencia Region.

The role of European clusters as innovation ecosystems, and their implication in the successful international promotion of the membership companies is key, specially in the Chinese market (a political economy where the Government plays a central role in the economy). This situation explains that private Chinese companies and institutions they feel more comfortable when a public association, such as European clusters, are involved in international programs with the objective of promoting business activities between our countries.

Keywords: Chinese market, Energy and Industry 4.0, net zero emissions, smart cities, smart ports and smart factories, clusters or sectorial associations, public private partnerships, Valencia region (Spain)

Introduction

The role of clusters contributing to company's internationalization is key, as a non-profit organisation set up with the objective to foster competitiveness in the industrial sector, the cluster currently comprises innovative businesses and research centers: energy sector operators, equipment and component manufacturers, engineering firms, service companies, research, technology centers and universities. Main functions of the cluster to contribute to better results of their members in the international markets should be described as:

- The cluster as an attractive pole of relevant information for the industry (updated technology and financial tools and European programs).
- The cluster as a connector with other international public institutions, as they understand well the need of being a member of a wide ecosystem outside our country.
- Specially in the Chinese market, public and private companies are more friendly to do business with other European companies enrolled in a public association, the role of the clusters when approaching the Chinese market, it is very relevant contributing to the particular success of the private companies joining the international cooperation programs (Irún et al. 2021).

In order to develop innovative projects in the fields of smart cities, smart ports and smart factories contributing to the achievement of the Sustainable Development Goals defined in the UN 2030 Agenda (UN Assembly, 2015), the final objective of an international cooperation program is:

- Mapping opportunities for enterprises for climate-neutral and smart cities, ports and factories markets contributing to achieve the strategic objectives established in the EU and China mission plans 2030 concerning these sectors which are aligned with the 2030 Agenda for Sustainable Development.
- Strengthen current and develop new partnerships and commitment for long-term collaboration in these fields.
- Investigate possibilities for combining local, regional, national, European and Chinese-international funds for scaling and making the climate-neutral, smart cities, ports and factories markets more mature.

The 2030 Agenda positions science, technology and innovation (STI) as a key means of achieving the Sustainable Development Goals. The 17 Sustainable Development Goals (SDGs) define global priorities and aspirations for sustainable development by 2030 and seek to mobilize global efforts to achieve common goals and targets. The SDGs call on governments, businesses and civil society to take global action to end poverty and create lives of dignity and opportunity for all within the planet's borders. The clusters acts as an industry group to promote the penetration of innovative technologies in the smart city, smart port and smart factory markets to achieve the 2030

goals and to help cities, governments and organizations align their goals strategies with the SDGs offering novel solutions and technologies to put sustainability at the heart of their development strategy. The key SDGs related to the climate-neutral and smart cities, smart ports and smart factories sectors are:

- SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all.
- SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
- SDG 11: Sustainable cities and communities.
- SDG 13: Take urgent action to combat climate change and its impacts.
- SDG 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Cities, Ports and Factories of the Future: R&D Strategies and Priorities in Europe

Introduction to Smart Cities, Smart Ports and Smart Factories

Smart cities. A smart city (see definition provided by the initiative U4SSC[1]) is a framework, predominantly composed of Information and Communication Technologies (ICT), to develop, deploy, and promote sustainable development practices to address growing urbanization challenges. A big part of this ICT framework is an intelligent network of connected objects and machines (also known as a digital city) transmitting data using wireless technology and the cloud. Cloud-based IoT applications receive, analyse, and manage data in real-time to help municipalities, enterprises, and citizens make better decisions that improve quality of life.

[1] The "United for Smart Sustainable Cities" (U4SSC) is a UN initiative coordinated by ITU, UNECE and UN-Habitat, and supported by CBD, ECLAC, FAO, UNDP, UNECA, UNESCO, UNEP, UNEP-FI, UNFCCC, UNIDO, UNOP, UNU-EGOV, UN-Women and WMO to achieve Sustainable Development Goal 11: "Make cities and human settlements inclusive, safe, resilient and sustainable."

Smart ports. The concept of smart ports (Smart Ports Piers of the Future, 2020[2]) is centered on using digital technology to transform sea transport and logistics. It's important to keep in mind that this is a tool for facilitating global change. Smart ports must be more ecological, efficient, and socially responsible, in addition to being intelligent and networked. It is a long-term transformation strategy that will affect all aspects of sea transportation and introduce technologies such as automation, self-driving vehicles, blockchain, and the Internet of Things to port operations.

Smart factories. Industry 4.0 (see definition provided by EFFRA[3]) is the digital transformation of manufacturing/production and related industries and value creation processes. Industry 4.0 is used interchangeably with the fourth industrial revolution and represents a new stage in the organization and control of the industrial value chain. Cyber-physical systems form the basis of Industry 4.0 (e.g., 'smart machines'). They use modern control systems, have embedded software systems and dispose of an Internet address to connect and be addressed via IoT (the Internet of Things).

The smart factory, a typical term from the Industry 4.0 and it is often linked to its enabling technologies, essentially revolving around Industrial IoT, big data analytics, production techniques, connected physical equipment and what can be done with it in a cyber-physical scope: the Internet of Things and sensors, the mentioned convergence of IT and OT, new means of manufacturing, (cloud-based) platforms, enabling technologies (Artificial Intelligence, Machine Learning, etc.), interoperable and highly connected systems/platforms and the analysis and usage of data from ample sources including machines, turned into actions and decisions (automation and semi-automated), play an essential role in it.

[2] Smart Ports: Piers of the Future 2020 is a congress on innovation, sustainability and digital transformation organized by Port de Barcelona and joined by the ports of Antwerp, Hamburg, Los Angeles, Montreal, Rotterdam and Busan. During the 17th & 18th of November 2020 the world's largest and most influential ports will be sharing their innovative projects on Drones, Digital Twin, Green Smart Ports and Smart Port Cities among many others.

[3] The European Factories of the Future Research Association (EFFRA) is a non-for-profit, industry-driven association promoting the development of new and innovative production technologies. EFFRA has been representing the private side of the manufacturing partnership with the EU Commission. Named under Horizon 2020, Factories of the Future to become Made in Europe nowadays under Horizon Europe.

Towards Next Generation of Cities, Ports and Factories: Application of Green Environmental Protection and Smart Technologies

In an effort to be a net-zero emissions region by 2050, the European Union has established their plan for transforming the practices of various high-contributing sectors, in particular cities, ports and industry. While the European Green Deal aims to decrease emissions by 50% compared with 1990 levels by 2030, it also hopes to encourage competitiveness in Europe's economy at the same time. All of this work is expected to put sustainability and the well-being of citizens at the center of the EU's policy making and action. "It is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use." (European Green Deal, 2019).

A city, port or industry factory plays a catalyst role in world economic. The fifth generation cities, ports and factories adapt to the green and intelligent technology innovation trend, emphasizing that the city, port, factory of the future must fit the concept of green environmental protection and high-tech technology.

European R&D Policies and Priorities for the Period 2021-2027

The European Commission is the executive body of the European Union (EU). Under the Treaties, its tasks are to 'promote the general interest of the Union', without prejudice to individual Member States, to 'ensure the application of the Treaties' and adopted measures, and to 'execute the budget'.

The European Commission has made it clear that it sees the coronavirus crisis as reconfirming the relevance of its existing priorities, rather than eclipsing or recasting them. It also sees the crisis as offering an opportunity to move further and faster in certain fields, talking about 'the great acceleration of change' which the crisis has unleashed and 'the great opportunity it has paradoxically presented'. This attitude is notably the case with the two most ambitious of the six priorities – 'A European Green Deal' and 'A Europe fit for the digital age' – where the Commission has sought to use the momentum of events surrounding the crisis not only to assert the increased relevance of these priorities – suggesting that radical changes in human behaviour are possible and that these are likely to be driven in large measure by digital innovation – but to operationalize them further through the €750 billion "Next

Generation recovery fund," which itself helps carry forward the third priority, "An economy that works for people." Defined percentages of the Recovery and Resilience Facility, the key element of NGEU, are to be used for investment in initiatives that will advance Europe's move to climate-neutrality as a continent by 2050 and in digital modernization of various kinds (37 and 20 per cent respectively).

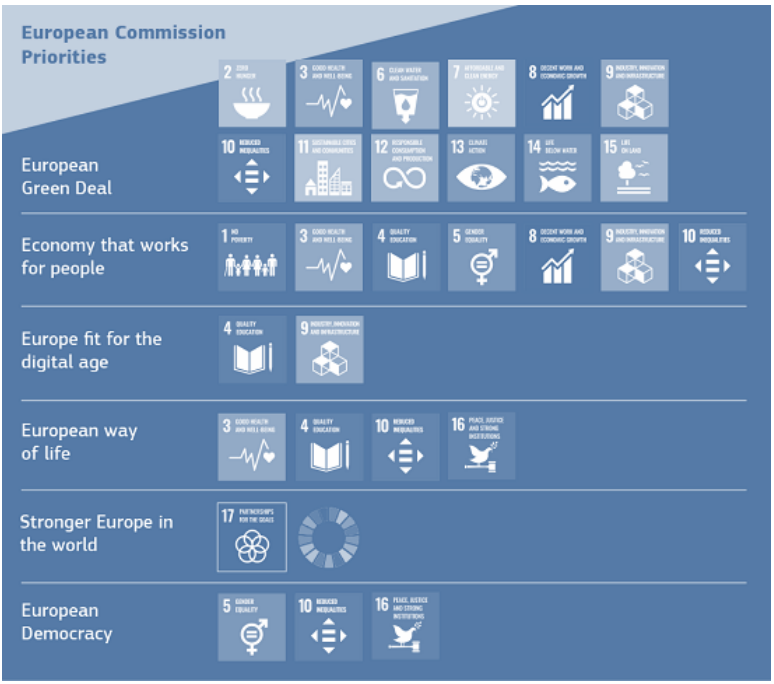
Sustainable development is a core principle of the Treaty on European Union and a priority objective for the Union's internal and external policies. The United Nations 2030 Agenda includes 17 Sustainable Development Goals (SDGs) intended to apply universally to all countries. It is a commitment to eradicate poverty and achieve a sustainable world by 2030 and beyond, with human well-being and a healthy planet at its core. The Sustainable Development Goals (SDGs) were set in 2015 by the international community as part of the UN 2030 Agenda for Sustainable Development through which countries of the world collectively pledged to eradicate poverty, find sustainable and inclusive development solutions, ensure everyone's human rights, and generally make sure that no one is left behind by 2030. Europe is committed to implement the SDGs in all the EU policies and encourage EU countries in doing the same. 17 SDGs have been defined, with 169 associated targets, to be reached by 2030 (Eurostat, 2021).

EU Holistic Approach to Sustainable Development

The European Commission remains committed to the 2030 Agenda. Under the leadership of President von der Leyen, the Commission has presented an ambitious policy programme to deliver on sustainability in the EU and beyond. The Sustainable Development Goals (SDGs) are an intrinsic part of the President's political guidelines and lie at the heart of the policymaking on internal and external action across all sectors. Full implementation of the United Nations' 2030 Agenda is crucial to strengthen resilience and prepare the world for future shocks as we embark on the twin green and digital transitions[4].

The President's political programme integrates the SDGs into all Commission proposals, policies and strategies. All of the 17 SDGs feature in one or more of the six headline ambitions announced in President von der Leyen's Political Guidelines as depicted in the Figure 1.

[4] Governments everywhere are urging not only industry but also consumers to go easy on the planet's precious raw materials. And Europe is banking on innovation as a driving force in achieving its so-called twin (green and digital) transition to a zero carbon, zero waste economy that leaves no person or place behind.



Source: European Commission Priorities. Publication 2015.

Figure 1. Image agenda: Sustainable development goals.

The Role of Clusters Fostering Sustainability and Smart Strategies in Cities, Ports and Factories

When clusters and its members (private enterprises and RTD performers) are actively participating in networks, platforms, and innovative projects in order to implement sustainability and smart strategies in cities, ports and factories, they achieve the specific SDGs described below:

- SDG 11: Sustainable Cities and Communities. The 11th Sustainable Development Goal (SDG11) aims at addressing the challenges brought by urbanisation and making sure cities are inclusive, green, safe, and managed sustainably, notably by:
  - ensuring access for all to adequate, safe, sustainable, and affordable housing, transport, and basic services by 2030 in urban settings

- improving cities' waste management, air quality, urban planning, and infrastructure to reduce their adverse environmental impact, and improve their resilience to disasters
- providing universal access to safe, inclusive, accessible, and green public spaces by 2030, especially for the most vulnerable groups (women, children, the elderly, and disabled people).

According to the UN, 3.5 billion people currently live in cities and with the exponential urbanisation of developing countries, global urban population is expected to reach 5 billion by 2030. While occupying just 3% of the Earth's land, cities account for roughly 3 quarters of the world's total energy consumption and carbon emissions. More than 800 million people live in slums and more than half of all urban dwellers in the world are breathing air polluted at levels at least 2.5 times higher than the safety standard.

Europe is committed to achieve SDG11 because sustainable urbanisation is an essential tool to make sustainable development a reality at local level. The support EU provides to urban and peri-urban areas in partner countries therefore addresses aspects that can improve the quality of life in cities. It combines diverse efforts related to access to water and sanitation, urban mobility, affordable and sustainable housing, energy efficiency etc. Moreover, given their concentration of people, cities are particularly vulnerable to climate change and disasters, which is why EU also help them build their resilience to minimise potential human and economic losses from future shocks.

- SDG 9: Industry, innovation, and infrastructure. The 9th Sustainable Development Goal (SDG9) pursues 3 interdependent objectives that are fundamental to empower communities and achieve sustainable economic growth and development around the world, without leaving anyone behind:
  - Resilient infrastructure: develop quality, reliable, sustainable, and resilient infrastructure, accessible for all in an affordable and equitable way
  - Sustainable industries: promote inclusive and sustainable industrialisation, with the aim of doubling industry's share of employment and revenue in the least developed countries (LCDs) by 2030 and improving access to finance for small-scale industrials

- Innovation: encourage innovation, scientific research, and technological upgrades to make infrastructure and industries more sustainable and respectful of the environment

According to the UN, developing countries have a huge yet underexploited potential for industrialisation and innovation. For example, the manufacturing value added per capita in LCDs is 45 times lower than in Europe and, in developing countries, only 30% of agricultural production undergoes industrial processing, compared to 98% in high-income countries. Basic infrastructure –roads, energy grids, water and sanitation infrastructure, and information and communication technologies – remain scarce in developing countries: approximately 1.2 billion people don't have access to reliable phone services, 2.3 billion people lack access to basic sanitation, and nearly 800 million people lack access to water. These constraints also affect the overall productivity rates of developing countries, especially in Africa. Moreover, unsustainable industrial processes causing high carbon dioxide emissions too often remain the norm in developing countries.

Achieving SDG9 is an essential part of EU cooperation work. Developing better infrastructure is crucial to eventually improve human well-being and industrial productivity and competitiveness. Through blending, EU invests in infrastructural projects that have a multiplier effect on EU partner countries' sustainable development. EU supports partner countries' industrial transition towards sustainable processes and technologies, which will allow them to increase their productivity and competitiveness, while respecting the environment. EU also acts to improve access to financial services and technologies in our partner countries, in line with our ambition to leave no one behind and foster inclusive growth.

European Union (EU) policy approach to sustainable development is broad and inclusive. Europe work on SDG9 is closely linked to other SDGs and includes credit and research for technological advances, developing value chains, and promoting good business practices. Together with EU countries, one of EU priorities is to support the extension of broadband connectivity and digital infrastructure, especially in rural areas, and to promote digital literacy, skills, and entrepreneurship, including among women and young people (United Nations, 2015).

Horizon Europe Programme: R&D Priorities in Sustainable Smart Cities, Smart Ports and Smart Factories

Horizon Europe is the EU's research and innovation programme for 2021-2027 with a budget of €95.5 billion. It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth. The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It supports creating and better dispersing of excellent knowledge and technologies. In particular, the European Commission has defined different missions and clusters in order to foster the development of innovative solutions and projects in the different sectors addressed: smart cities, smart ports and smart factories:

- Mission Area 4: Climate-Neutral and Smart Cities. Reaching 100 climate-neutral cities by 2030 is the objective identified by the Mission Board for climate-neutral and smart cities. A Mission in this area would support, promote and showcase 100 European cities in their systemic transformation towards climate neutrality by 2030 and make these cities into experimentation and innovation hubs for all cities.
- Cluster 4 (Digital, Industry and Space) will support the development and mastery of digital and key enabling technologies of the future. This will increase adaptability and resilience to improve production response, recovery and preparedness to deliver on a green, digital and fair transformation and give EU industries across all sectors the competitive edge they need for leadership in global markets. Investments under this cluster will support the EU to seize opportunities in key parts of the digital supply chain, to consolidate EU assets (e.g., embedded systems, telecom, and industrial technologies) and develop missing segments in key strategic value chains, including secure, sustainable, responsibly sourced supply of raw and critical raw materials.
- Cluster 5 (Climate, Energy and Mobility) will support Europe's green transition based on competitive European industrial and service value chains, in particular in the energy and mobility sector (in particular in EU ports) which represent markets that are predicted to substantially grow globally. Targeted research and innovation support will enable

cleaner and more competitive energy and mobility solutions and digitalised services crucial for a competitive European economy and will benefit society and citizens by offering a better quality of life and millions of new qualified green and future proof jobs.

Climate-Neutral and Smart Cities

Climate-Neutral and Smart Cities Strategy in Europe

A smart sustainable city/community (see definition The United Nations Economic Commission for Europe UNECE standard[5]) is an innovative city that uses ICTs and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects.

Horizon Europe is the EU's key funding programme for research and innovation with a budget of €95.5 billion. It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth. The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It supports creating and better dispersing of excellent knowledge and technologies. It creates jobs, fully engages the EU's talent pool, boosts economic growth, promotes industrial competitiveness and optimises investment impact within a strengthened European Research Area. There are 5 main mission areas as part of Horizon Europe. EU missions are commitments to solve some of the greatest challenges facing our world like fighting cancer, adapting to climate change, protecting our oceans, living in greener cities and ensuring soil health and food.

They are an integral part of the Horizon Europe framework programme for the years 2021-27. Each mission will operate as a portfolio of actions – such as research projects, policy measures or even legislative initiatives - to achieve a measurable goal that could not be achieved through individual

[5] SSC – Smart Sustainable City. A smart sustainable city is an innovative city that uses innovative solutions and technologies to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects.

actions. EU missions will contribute to the goals of the Recovery Package, the European Green Deal, Europe's Beating Cancer Plan as well as the UN's Sustainable Development Goals.

In particular, the EU mission neutral-climate and smart cities has been defined. Reaching 100 climate-neutral cities by 2030 is the objective identified by the Mission Board for climate-neutral and smart cities. A Mission in this area would support, promote and showcase 100 European cities in their systemic transformation towards climate neutrality by 2030 and make these cities into experimentation and innovation hubs for all cities (EU Missions, 2021).

Cities are the place where decarbonisation strategies for energy, transport, buildings and even industry and agriculture coexist and intersect. The climate emergency must be tackled within cities and by engaging citizens who are not only political actors in a governance structure, but also users, producers, consumers and owners. Through a multi-level and co-creative process formalised in a Climate City Contract, adjusted to the realities of each city, the Mission is fully anchored on the European Green Deal Strategy to make Europe climate neutral by 2050.

The introduction of a Climate City Mission is a radical new way of achieving climate neutrality – and of doing so faster, by 2030. The Mission aims to promote system innovation across the value chain of city investment, targeting multiple sectors such as governance, transport, energy, and construction and recycling, with support from powerful digital technologies. As such, it requires a change in regulations, approaches and instruments combined with the willingness to go beyond existing schemes and habits. The Climate City Mission also demands a change of attitude towards practical aspects of implementation, but also as concerns people and organisations working together: citizens, local governments, central and regional governments, and European institutions.

Why a mission on climate neutral cities? Mitigating climate change at a global scale is a huge challenge and the time for the necessary societal transformation is short. Cities cover about 3% of the land on Earth, yet they produce about 72% of all global greenhouse gas emissions. On top of that, cities are growing fast; in Europe, it is estimated that by 2050 almost 85% of Europeans will be living in cities. Therefore, the climate emergency must be tackled by cities – and by citizens.

SDG 11: Make Cities Inclusive, Safe, Resilient and Sustainable Climate-Neutral and Smart Ports

The world is becoming increasingly urbanized. Since 2007, more than half the world's population has been living in cities, and that share is projected to rise to 60 per cent by 2030. Cities and metropolitan areas are powerhouses of economic growth—contributing about 60 per cent of global GDP. However, they also account for about 70 per cent of global carbon emissions and over 60 per cent of resource use. Rapid urbanization is resulting in a growing number of slum dwellers, inadequate and overburdened infrastructure and services (such as waste collection and water and sanitation systems, roads and transport), worsening air pollution and unplanned urban sprawl. The impact of COVID-19 will be most devastating in poor and densely populated urban areas, especially for the one billion people living in informal settlements and slums worldwide, where overcrowding also makes it difficult to follow recommended measures such as social distancing and self-isolation.

Key 2030 goals have been defined related to SDG 11:

- 11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums.
- 11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.
- 11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.
- 11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage.
- 11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.
- 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

- 11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities
- 11.A Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning.
- 11.B By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels.
- 11.C Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials.

Smart Cities Strategy in Asia

China

China is a leading country in the creation of smart cities, digitalizing urban areas by using big data processing and analysis powered by artificial intelligence (AI) to help manage resources and public spaces for urban living. Smart cities aim to enhance the efficiency and quality of the everyday life in areas such as mobility, communication, shopping and housing, mainly with the use of technology such as connected devices, big data and cloud computing. The development of smart cities in China is primarily top-down and predominantly driven by government investment, but there is significant opportunity for partnership with private tech companies looking to transform urban living. At the same time, the development of smart cities aligns with China's regional development plans as most projects are located along the more economically developed eastern seaboard (Eusme, 2018).

Currently, China has about 800 smart city pilot programs under way, which is more than half of the world total. In doing so, the government strives to promote deep integration of next-generation IT with housing and urban-rural development, as well as foster high-quality development. The smart cities initiative was established in the 12th Five-Year Plan issued in 2011. Over the years, Shanghai, Beijing, Guangzhou, Xi'an, Yinchuan and

Hangzhou have become examples of older urban areas that have been transformed. For instance, in Hangzhou, the "City Brain" system designed by Alibaba has been in use since 2016. An AI system that uses big data and computing power to monitor, improve and fix traffic problems, it has successfully helped reduce traffic congestion by 15%. It will be interesting to see how smart cities evolve over the coming years and how their "digital brains" and big data-driven initiatives can help improve quality of life and protect the environment, as well as create new possibilities in how we live and work in the post-COVID-19 world.

Smart City Singapore: Virtual Singapore Project

Virtual Singapore is a dynamic three-dimensional (3D) city model and collaborative data platform, including the 3D maps of Singapore. When completed, Virtual Singapore will be the authoritative 3D digital platform intended for use by the public, private, people and research sectors. It will enable users from different sectors to develop sophisticated tools and applications for test-bedding concepts and services, planning and decision-making, and research on technologies to solve emerging and complex challenges for Singapore.

This project is championed by the National Research Foundation (NRF), Prime Minister's Office, Singapore, the Singapore Land Authority (SLA) and the Government Technology Agency of Singapore (GovTech). NRF will be leading the project development, whilst SLA will support with its 3D topographical mapping data and become the operator and owner when Virtual Singapore is completed. GovTech will provide expertise in information and communications technology and its management as required in the project. Other public agencies will participate in Virtual Singapore in various phases.

Virtual Singapore is an R&D programme initiated by the NRF at a cost of $73 million for the development of the platform as well as research into latest technologies and advanced tools over a period of five years. The platform is targeted to be ready by 2018 and will be deployed progressively. There are ongoing collaborations with government agencies, universities and partners to leverage Virtual Singapore for their modelling and simulation needs (EDB, 2021).

Smart Technologies/Solutions for Sustainable Smart Cities and Communities

The Role of Digital Technologies

As city populations grow, the demand for services and the pressure on resources increase. This demand puts a strain on energy, water and mobility services, which are fundamental to a city's prosperity and sustainability. At the same time, cities and communities are undergoing a digital transition process which needs to be appropriately implemented.

With this in mind it is evident that making our cities and communities climate neutral and smart is an absolute need for achieving the 'twin green and digital transformation'. The diffusion of ICT is essential for stimulating economic development and boosting economic activity in cities. Europe's digital policy and initiatives (such as the new Digital Europe programme) will support and accelerate the transition to sustainability for cities and communities through digital, in particular by building high quality connectivity infrastructure, developing a digital environment that empowers end-users, respects European values and norms, encourages the development of skills, and brings long-term growth opportunities across all sectors of the European economy.

ICTs could deliver approximately 7.8 GtCO2e of emissions savings, representing around 15% of total emissions in 2020. Examples of projects that could have a great impact include stability, effectiveness and safety of low (zero) carbon electric grids, automated disassembly and separation of waste using AI and robotics. On top of these processes, ICT can also help prevent significant damage arising from disruptive weather patterns and phenomena, through climate impact modelling for optimal mitigation and adaption. This will allow for a wide collection and better access to the wide range of environmental "big" data and also help engage with citizens using digital tools.

In particular, ICT-based solutions could reduce commuting by 15–20% and cut greenhouse gas emissions by 10–15% (McKinsey Global Institute), while urban digital twins could significantly improve cities' ability to simulate or model policy outcomes, given that today only 12% of city data is analysed and used for decision making and management. An increasing amount of data is also being collected by various ICT and social media technologies that could support the cities' and communities' transformation. To this end, the planned creation of common European dataspaces, in particular the Green Deal dataspace, will be an important step to develop the digital ecosystem of the

environment. One of its early deliverables will be the creation of a data ecosystem for climate-neutral and smart communities, which will facilitate the access, share and re-use of locally-relevant data (in areas such as mobility, energy, climate and zero pollution) and as such can serve as the underlying digital infrastructure for the cities supported by the Mission.

Therefore, the Smart Cities Mission will need to be powered by a proper framework and by digital solutions that (i) allow the management of cross-domain data (interoperable platforms and mechanisms for data sharing) and (ii) also help cities pursue their digital transformation their own way, i.e., by preserving their security, flexibility as well as their data and technological sovereignty when adopting technological solutions.

Key Areas to Be Addressed and Incentivised to Work on New Solutions

These are the key innovation areas to be addressed in the field of smart cities (Mission Climate-Neutral Smart Cities, 2020):

- Digital solutions, making cities and communities climate neutral and smart is an absolute need for achieving the 'twin green and digital transformation' in the EU. The diffusion of ICT is essential for stimulating economic development and boosting economic activity in cities. Urban platforms are the implementation of a logical architecture that integrates data flows across city systems, exploits digital technology sensors, cloud, mobile applications, and social media management.
- Energy efficiency, aiming at zero emissions to reach the full potential of energy efficiency - especially in the buildings sector that accounts for 40% of energy demand.
- Deployment of renewables and use of electricity to fully decarbonise Europe's energy supply.
- An efficient mobility for all, clean, safe and accessible including carbon free and alternative fuels, promotion of public transport, walking and cycling, smart multimodal solutions such as mobility as a service (MaaS), and automation.
- Integration of the circular economy approach that employs reuse, sharing, repair, refurbishment, remanufacturing and recycling in a close-loop system for minimising the use of resource inputs and the creation of waste, pollution and carbon emissions.

- Reaping the full benefits of bio-economy and create essential carbon sink since both global and European assessments confirm that a net-zero emissions economy will require increasing amounts of biomass compared to today's consumption.
- Optimizing the carbon footprint of Gigabit society as the latter becomes an increasingly important part of the society and economy.

Green and Smart Ports

Sustainable and Smart Ports Strategy in Europe

Smart Ports Definition

The fairly new concept of a 'Port of the Future' enables policy makers and companies to identify successful strategies they can adopt, and pitfalls they can avoid, when drafting and implementing sustainable port growth policies. The uncertainty and potential impacts of climate change are the primary driving forces behind sustainable actions in coastal protection, port management and operational planning.

Smart ports is the new generation of ports that are both drivers and facilitators of the transition of the ports-logistics sector to Economy 4.0. They have become innovation clusters that improve efficiency, security and sustainability of the trade sector. Hence, they also foster increased competitiveness of the whole productive system, providing a boost to it through the introduction in public and private sectors of new disruptive technologies in the scope, among others, of digitalization, automation, decarbonization, connectivity and monitoring and/or artificial intelligence in the management of transport and logistics.

Green Deal Strategy and Smart Ports

One major area that's garnering attention is the maritime sector, which, according to the deal, "should become drastically less polluting" in order to adhere to their current guidelines for achieving sustainable development goals. As the point of passage for people, goods, and various transport modes, ports play a major role in the success of the European Green Deal. With waterborne transport accounting for approximately 90% of global trade and 2.5% of global GHG emissions, the spotlight is on port authorities to contribute to creating a sustainable mobility that will support the economic prosperity of the region.

The European Commission has scheduled a set of measures for a more sustainable and smart mobility in ports. For that reason, under the European Green Deal, ports will have to follow environmentally responsible codes that will include measures such as:

- A new strategy focused towards sustainable and smart mobility.
- A funding call to support the deployment of public recharging and refuelling points as part of alternative fuel infrastructure.
- The assessment of legislative options to boost the production and supply of sustainable alternative fuels for different transport modes.
- Revised proposals for a Directive on Combined Transport.
- A review of the Alternative Fuels Infrastructure Directive and the Trans-European Network within Transport Regulation.
- Initiatives to increase and better manage the capacity of railways and inland waterways.
- A proposal for more stringent air pollutant emissions standards for combustion-engine vehicles.

But creating cleaner ports means more than just making transport more sustainable. Although they're most well-known as interconnection points within the maritime transportation network, they also exist as multimodal nodes, industrial areas and commercial sites. Hence, all stakeholders must be aware of their emissions in order to achieve change from the sector as a whole. This means a focus must be cast towards industries such as oil refineries, chemical clusters, regasification plants, cement, iron and steel industry, leisure activities such as cruises and yachting, and even the port-city relationship.

According to position paper of the (European Sea Ports, 2018) "this requires support for large investments in the provision of clean energy, connectivity of energy infrastructure networks and green grids (both pipelines and cables), as well as support for innovative technological projects in and between ports; in addition, ports can also attract new investments in clean energy and technology and, at the same time, it is important to guarantee the security of energy supply for these industry hubs throughout the energy transition; ports can also become important producers and providers of clean energy solutions for the economy and are an ideal location to develop circular economy projects, both the presence of industry and the proximity to large urban agglomerations make them ideal places to turn waste into products."

The Horizon Europe R&D programme will support the development of projects of this nature. To create eco-ports as hubs for sustainable mobility, Horizon Europe funding programme as a powerful financial instrument will help to secure Europe's global competitiveness, its main aim is to foster the implementation of the deal.

Trade Sustainability - The Tradetech Sector: Innovation to Support Logistics, Trade, Passenger and Goods Transport, and Other Associated Sectors

Since the dawn of our history, trade has always been the main lever for the development of society. The exchange of goods (often coming from all four corners of the earth) has allowed us to evolve thanks to the discovery of new foods, materials and technologies with which we have innovated and transformed our way of life. In recent decades, globalization and the digitalization of purchasing processes have led to the boom in global trade and logistics as well as the industries that support it such as infrastructures, transport and logistics. But, at the same time, the energy consumption, the waste generated, and the impact on the environment have risen, putting the sustainability of the planet's resources at risk forever.

Furthermore, the fourth industrial revolution (Industry 4.0) has led to the disruptive transformation of all economic sectors resulting in the creation of innovative products, services and processes through the use of the latest cutting-edge technologies. These transformative processes not only apply to the trade, logistics and transport sectors, encompassing each and every component and link in the logistics chain, but in particular, to the ports due to the key role they play as inter-connected element in the chain. The European and Chinese economy is aware of this importance and understands that the best conditions for international projection depend on leveraging the privileged position it enjoys with regard to both the maritime routes, and of the potential of its ports and of the entire port- logistics community. The concept of TradeTech arises, one which encompasses any technology or innovative solution that allows for the transformation of any of the services or processes related to the following: trade activities, the logistics chain, transport and ports, such as freight and passenger transport, distribution, storage and logistics, safety and security, the decarbonisation and reduction of emissions, construction and maintenance of logistics infrastructures and assets, and also tourism, nautical sports and fishing.

A clear commitment of the European Green Deal is that "transport should become drastically less polluting," highlighting in particular the urgent need

to reduce greenhouse gas emissions (GHG) in aviation and waterborne transport. Waterborne transport accounts for approximately 90% of global trade and 13% of EU transport GHG emissions, while also experiencing continuous growth. In this context, maritime and inland ports play a major role, both as inter-connection points in the respective transport networks, but also as major multimodal nodes, logistics hubs and commercial sites, linking with other transport modes, hinterland connections and integrated with cities. As such, green ports, as multimodal hubs in the post COVID-19 era for sustainable and smart mobility have a great potential to immediately contribute to start driving the transition towards GHG-neutral aviation, shipping and wider multimodal mobility already by 2025.

Sustainable and Smart Ports Strategy in China: The 21st Century Maritime Silk Road

As the second largest economy in the world, 7 of the world's top 10 container ports are located in China, which handle 30% of the world's containers every year. However, it is the world's largest emitter which contributed 23% of GHG emissions. China's port governance has been reformed extensively over the last decade, from centrally owned and managed ports to mixed ownership between central and local governments, to in most cases entirely local. Moreover, several ports have been merged into regional port authorities, in an effort to reduce wasteful competition between neighbouring ports and focus transport investment on intermodal corridors in the hinterland, supported by additional central government policies which still influence port management. China as a member state is working hard to be in line with recent IMO environmental regulations. The state council of PRC put high priority on "green transportation" and "low carbon economic development" in China's 12th Five-Year Plan (2011-2015) and 13th Five Year Plan (2016-2020). New executive planning was released by China's Ministry of Communications (MOC) in 2015 including a plan for three Emission Control Areas (ECAs) requiring ships calling at the Pearl River Delta (PRD), the Yangtze River Delta (YRD) and the Bohai Bay to switch to lower sulphur fuel (no more than 0.5%m/m). This clause would apply on all national ships entering the three port regions and suggest international ships to change to lower sulphur fuel according to IMO regulation in ECAs. The Ministry of Communication set the goal that 10,000 vessels in the inland water fleet should be running on LNG by 2020.

The state council also pays attention to reducing emissions from port production activities. In 2016, the state council made an amendment to the existing Law about Prevention and Treatment of Air Pollution; the newly added No. 63 clause states that "vessels staying at berth should use on-shore power as the first choice." Moreover, the "Special action plan for the prevention and control of pollution from ports and ships" mentioned that 50% of container ship berths in main port terminals should have the ability to provide shore side electricity for ships. China Ports & Harbours Association is the national society applying the maritime policies of the Chinese government. In 2015, this organization published "Guideline for Green Port Rating System (Trial Implementation)" as a self-evaluating guide book for ports and a guideline for third parties to rank the green performance of ports. Listed tools include using intelligent control technology for outdoor lighting, changing the power of RTGs to electricity, using LNG or electric powered vehicles in port, taking measure to protect terminals' water ecosystem and the harbour district, operating risk assessments on the local ecosystem in port expansion projects and developing environmental pollution emergency plans for security production (Chen et al. 2017). However, in fact, before the guidebook came out, some individual ports had been making their own progress on green port management and evaluation. Shanghai Port Administration Centre used to publish a report on the environmental protection of Shanghai Port which indicated the Shanghai Municipal Port Administration Bureau was responsible for the supervision and management functions of the greening process of the port.

Mitigating emissions from inland transport is at the early stages in China. Although China's 13th five year plan and "Belt and Road Initiative" stress the development of intermodal transport in port distribution, there remains a lack of attention to this topic from the environmental perspective.

Consequently, it can be seen that the Chinese government has started its first steps following international regulations and experiences from developed countries in terms of green port strategies, however.

The Belt and Road refers to the "Silk Road Economic Belt" and "the 21st-Century Maritime Silk Road-MSR," aiming to strengthen links with infrastructure in Central Asia, Southeast Asia, and other regions. As important strategic nodes of the MSR and nodes of global trade circulation, ports play an important role in the economic development of countries along the MSR. The countries along the MSR differ greatly in infrastructure, especially in port and terminal facilities. This are reflected in the gap between African countries and European countries, especially Yemen and Syria in West Asia, and Sudan

and Djibouti in Africa, where the efficiency of port logistics is generally low. Some countries with poor economic development and low levels of foreign trade tend to have low logistics efficiency of ports. It is due to insufficient national financial resources and the difficulty of implementing huge investment projects in ports, which leads to high transportation costs. In general, under “Belt and Road” strategy, there are great opportunities for Chinese terminal operators to invest, manage and operate overseas terminals. Therefore, the construction of container terminals along the MSR have attracted more and more attention from Chinese terminal operators.

Smart Technologies/Solutions for Climate-Neutral and Smart Ports

Key areas/technologies identified in the Horizon Europe Programme and other R&D Programmes such as the National Programme Ports 4.0, to be addressed and incentivised to work on new solutions for green and smart ports include:

A. Logistical efficiency in the infrastructure, operational or service provision field
   - Automation and robotization of operations in ports (in any of their subsystems), as well as autonomous driving systems that may significantly improve port operations.
   - Unmanned vehicles: boats, mobile material in terminals, land transport.
   - "Efficient" or "Smart" infrastructures or facilities: new materials and designs, monitoring as a basis for optimizing predictive maintenance.
   - Infrastructures, facilities, equipment, processes or services that contribute to the increased accessibility for people with disabilities.
   - Infrastructures, facilities, equipment, processes or services that contribute to efficient and improved passenger and luggage care.
   - Infrastructures, facilities, equipment, processes or services that contribute to the improvement of the operation and management of border control and inspection centres (goods and passengers).
   - Infrastructures, equipment, processes or services that contribute to the improvement of the operation and management of fishing facilities.

- Infrastructure, equipment, services or processes that contribute to the improvement of the operation and management of the nautical sector.
- Promotion and enhancement of multimodal transport.
- Integration of real and forecast data of the physical environment in processes to improve the efficiency of the logistics chain and to reduce risks.
- Sensitization of port operations and the logistics chain.
- Systems of control for maritime and ground transportation.
- Traceability systems in the logistics chain.

B. Environmental sustainability and energy
   - Equipment associated with the provision of an eco-efficient port and commercial services from an environmental perspective.
   - Equipment, facilities or services that contribute to reducing the carbon footprint, polluting emissions and noise while improving water quality, and in particular any solutions that lead to a shift towards zero emission or Green Ports.
   - Equipment, facilities or services that contribute to the circular economy (waste recycling, treatment of material from dredging, wastewater, etc.).
   - Equipment, installations or services that contribute to the production or efficient management of energy in ports and logistics terminals.
   - Equipment, installations or services for forecasting and combating pollution.
   - Equipment, installations and services promoting the use of alternative fuels (LNG, etc.)

C. Security and Protection
   - Products (systems, devices, facilities, equipment or services) of early warning systems, detection or remediation of emergencies.
   - Remote sensing products on land, sea or air, as well as related to intrusion or passenger and cargo flows.
   - Optimization systems for physical or digital risk management (cyber security).
   - Automation of checks and controls.

D. Digitization of processes and intelligent platform
   - Digital platforms for management and data exchange between actors in the port-logistic community (extension or evolution of current single-window systems, management of services).
   - Intelligent port systems and co-creators of added value.
   - Digital integration with other modes of transport (goods/ passenger flows, rolling stock flows, service flows).
   - Registration and digital integration with other sectors: "big data," internet of things, etc.
   - Inclusive registration processes that ensure the reliability and transparency of information ("blockchain," etc.).
   - Info-connected port.
   - Products that contribute to the economy 4.0.

Smart Industry and Smart Factories

Smart Industry and Smart Factories Strategy in Europe: "Made in Europe"

Europe is embarking on a transition towards climate neutrality and digital leadership. The European industrial strategy aims to ensure that European industry can lead the way as we enter this new age. On 10 March 2020, the Commission laid the foundations for an industrial strategy that would support the twin transition to a green and digital economy, make EU industry more competitive globally, and enhance Europe's open strategic autonomy. As part of the Sustainable Industry Strategy defined by the European Commission, smart factories strategy plays a crucial role in order to achieve the 2030 goals defined in this strategy (Gheorghe, 2019).

Factories of the Future: Green and Digital Transformation of Industrial Ecosystems

EU aims to ensure that all industrial sectors in Europe can benefit from digital innovations with higher value digitalized products, more resource efficient production processes and new business models in response to evolving demand. EU through Horizon Europe Programme (2021-2024) manages the RD&I projects in the areas of embedded computing and cyber-physical systems and factories of the Future. EU ensures the coordination of the

implementation of the digitalization of industry strategy and notably the governance structure, the set-up of Digital Innovation Hubs and the development of digital industrial platforms. It follows the embedded systems activity within the ECSEL Joint technology Initiative and is co-responsible for the Commission's participation in the Factories of the Future.

'Factories of the Future' is the European Union's €1.15 billion public-private partnership (PPP) for advanced manufacturing research and innovation. It is the European Union's main programme for realising the next industrial revolution: materialising Factories 4.0.

The Factories of the Future Public- Private Partnership (PPP) initiative aims at helping EU manufacturing enterprises, in particular SMEs, to adapt to global competitive pressures by developing the necessary key enabling technologies to support EU manufacturing across a broad range of sectors. It will help European industry to meet the increasing global consumer demand for greener, more customised and higher quality products through the necessary transition to a flexible, digitalised and demand-driven industry with lower waste generation and energy consumption.

The PPP will concentrate on increasing the technological base of EU manufacturing through the development and integration of the key enabling technologies of the future, such as innovative technologies for adaptable machines, ICT for manufacturing, and the novel industrial handling of advanced materials. ICT plays an essential role in innovating production systems in all sectors. It allows notably for a more personalized, diversified and mass-produced product portfolio and for rapid and flexible reaction to market changes. The initiative will concentrate on industry-led R&D projects and will include demonstration activities, such as production-line demonstrators for validation and market uptake. The partnership will work together to identify the R&D needs of manufacturing industry and in particular SMEs. In order to further ensure the industrial character of the initiative, a large part of the activities in the projects is expected to be performed by industrial organisations themselves. This initiative, being by nature cross-sectorial and including efforts to address the needs of SMEs, aims at transforming Europe into a dynamic and competitive knowledge-based economy.

Progress in digital and industrial technologies shape all sectors of the economy and society. They transform the way industry develops, creates new products and services, and are central to any sustainable future. The COVID-19 pandemic has shown the necessity to strengthen Europe’s industrial base, enhancing its resilience and flexibility both in terms of technologies and

supply chains to reduce EU dependencies on third countries. It has also created a new urgency around addressing key societal challenges like sustainability or inclusiveness. In a globalised world of heightened uncertainties and volatile geopolitical interests, what is at stake is not only Europe's prosperity and economic competitiveness, but also its ability to autonomously source and provide crucial raw materials, technologies and services that are safe and secure for industry as a whole. Europe must develop and deploy technologies and reshape its industries and services towards a new reality, ensuring that industry can become the accelerator and enabler of this necessary change. Therefore the European Commission, in 'Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery', supported the European Green Deal and the Circular Economy Action Plan, alongside the digital strategies 'Shaping Europe's Digital Future', 'Data', 'Artificial Intelligence' White Paper, Digital Decade Communication and 'Space Strategy for Europe'.

The green transition and digital transformation are just at their beginning. Major opportunities lie ahead to position Europe as a technology and industrial leader of this transition. The proposed investments under Cluster 4 are targeted to realise the overarching vision a of Europe that shapes competitive and trusted technologies for a European industry with global leadership in key areas by enabling production and consumption respecting the boundaries of our planet, and maximising the benefits for all parts of society in the variety of social, economic and territorial contexts in Europe.

Horizon Europe is the research and innovation support programme in a system of European and national funding programmes that shares policy objectives. Through the programme, special attention will be given to ensuring cooperation between universities, scientific communities and industry, including small and medium enterprises, and citizens and their representatives, in order to bridge gaps between territories, generations and regional cultures, especially caring for the needs of the young in shaping Europe's future. Calls could be EU Synergies calls, meaning that projects that have been awarded a grant under the call could have the possibility to also receive funding under other EU programmes, including relevant shared management funds. In this context, applicants should consider and actively seek synergies with, and where appropriate possibilities for further funding from, other R&I relevant EU, national or regional programmes (such as ERDF, ESF+, JTF, EMFF, EAFRD and InvestEU), where appropriate, as well as private funds or financial instruments.

The Fundamentals of Europe's Industrial Transformation

The three drivers outlined above show the extent of transformation Europe will undergo. It takes a generation to transform an industrial sector and all the value chains it forms part of. But in a competitive and dynamic environment there is no time to waste. The next five years will be decisive to set the right enabling conditions for this transition. Underpinning this strategy are a set of fundamentals for Europe's industrial transformation. Some of these renew or expand on existing approaches in innovation, investment, standards or levelling the playing field. Others reflect the need for new ways of working for Europe to strengthen its industry for the transitions, whether it be on skills or circularity. The fundamentals reflect the fact that there is no silver-bullet or standalone solution – they are each inter-connected and reinforce each other. But they also reflect the reality that, while a lot can be done at the European level to enable and provide certainty, many of the levers are in the hands of others. A partnership approach will therefore be essential.

- Creating certainty for industry. A deeper and more digital single market. Thanks to the "unique single market," EU companies benefit from a springboard to compete globally. By providing a common regulatory space and scale, the single market is the driver of competitiveness and facilitates the integration of companies of all sizes in European and global value chains. To allow the single market to propel our industry forward, legislation must be implemented and enforced across the board. The Single Market Enforcement Action Plan adopted today puts forward concrete proposals to strengthen joint efforts in this area, notably the creation of a Single Market Enforcement Task Force. The Single Market Barriers Report6 shows the need to break down the barriers facing businesses when selling goods or more acutely when providing services cross-border. Enhancing tax harmonisation would help remove one of the main obstacles faced by business when operating cross-border, notably by making a common consolidated corporate tax base a reality. Single market legislation must also be reviewed and updated to ensure that it is fit for the digital age. But new forms of work must come with modern and improved forms of protections, including for those working on online platforms. The single market depends on robust, well-functioning systems for standardisation and certification. These help to increase the size of markets and provide legal certainty. Developing new standards and technical regulations, coupled with

increased EU participation in international standardisation bodies, will be essential to boost industry's competitiveness. The EU also needs to ensure that its Intellectual Property policy helps to uphold and strengthen Europe's tech sovereignty and promote global level playing field. IP helps to determine the market value and competitiveness of Europe's firms. This is their intangibles, such as brands, designs, patents, data, know-how, and algorithms. Smart IP policies are essential to help all companies to grow, create jobs and to protect and develop what makes them unique and competitive. An independent EU competition policy has served Europe well by helping to level the playing field, driving innovation and giving consumers more choice.

- Upholding a global level playing field. The openness of Europe's economy is at the source of its prosperity and competitiveness. Although, EU industry is highly integrated in global value chains and operates globally, the EU should not be naïve to threats to fair competition and trade. The EU works to keep markets open through trade deals with partner countries or regions or working in international fora to find rules that work for all. We must continue to take a coordinated European approach to secure mutually beneficial trade and overcome any barriers that prevent our businesses from properly accessing other markets around the world. This includes fighting aggressive tax planning schemes that create an uneven playing field. The EU will make the most of its full toolbox of trade defence mechanisms. By mid-2020, the Commission will explore how best to strengthen anti-subsidies mechanisms and tool. This will be done in the White Paper on an Instrument on Foreign Subsidies which will address distortive effects caused by foreign subsidies within the single market. This will be followed up with a proposal for a legal instrument in 2021. This distortion is often coupled with a lack of reciprocal access for European firms to the home country markets of foreign, state-owned companies. In particular, EU procurement markets are mostly open to businesses from countries where EU companies are discriminated 7 against or confronted with outright market closures.
- Supporting industry towards climate neutrality. As Europe transitions to climate-neutrality, certain sectors will have to make a bigger and more transformative change than most. Energy-intensive industries are indispensable to Europe's economy and are relied on by other

sectors. Modernising and decarbonising energy intensive industries must therefore be a top priority. The European Green Deal sets the objective of creating new markets for climate neutral and circular products, such as steel, cement and basic chemicals. To lead this change, Europe needs novel industrial processes and more clean technologies to reduce costs and improve market readiness. For instance, the Commission will support clean steel breakthrough technologies leading to a zero-carbon steel making process. The EU Emissions Trading System Innovation Fund will help deploy other large-scale innovative projects to support clean products in all energy intensive sectors. A new chemicals strategy for sustainability will help better protect people and the environment against hazardous chemicals and encourage innovation in the sector to develop safe and sustainable alternatives. A more sustainable built environment will be essential for Europe's transition towards climate-neutrality.

- Building a more circular economy. In line with Europe's new growth strategy, which gives back more than it extracts, Europe's industry must play a leading role in the ecological transition. This means reducing its carbon and material footprint and embedding circularity across the economy. To do this, we must move away from the age-old model of taking from the ground to make products, which we then use and throw away. We need to revolutionise the way we design, make, use and get rid of things by incentivising our industry. This more circular approach will ensure a cleaner and more competitive industry by reducing environmental impacts, alleviating competition for scarce resources and reducing production costs. The business case is as strong as the environmental and moral imperative. Applying circular economy principles in all sectors and industries has potential to create 700,000 new jobs across the EU by 2030, many of which in SMEs. The EU is already well placed in this field and should now focus on consolidating its first mover advantage. The new Circular Economy Action Plan8 puts forward a series of measures to allow the EU's industry to seize these opportunities. At the heart of it is a new sustainable product policy framework which will establish sustainability principles for all products, helping to make Europe's industry more competitive. Priority will be given to high-impact product groups and action will include initiative on the common charger, a circular electronics initiative, sustainability requirements for batteries, and new measures in the textiles sector. The Action Plan

also includes measures to empower consumers to play a more active role in the circular economy. Consumers should receive trustworthy and relevant information to choose reusable, durable and repairable products. The Commission will propose ways to improve consumer rights and protection, including by working towards a 'right to repair' for consumers.

Public-Private Partnerships

Public-private partnerships between industry and the European Commission helps tackle societal and environmental challenges. They have a strategic importance for the European industry, having an impact on its global technical lead, as well as on the economic growth and creation of new high-skilled jobs in Europe (Irún et al. 2020).

Made in Europe

Made in Europe is the successor to the Factories of the Future Partnership. The European Factories of the Future Research Association (EFFRA) represents the private side in the partnership. The 2030 vision for this sector is to reinforce the global position Europe's manufacturing industry in terms of competitiveness, productivity, and technology leadership. The partnership's budget of €1.8 million will seek to increase the number and attractiveness of jobs, while securing the environmental, economic and social sustainability for future generations in Europe and meeting the European Green Deal targets. The partnership "Made in Europe" will be the driving force for sustainable manufacturing in Europe. It will contribute to a competitive and resilient manufacturing industry in Europe and affects many value chains. Another priority is circular economy and following a circular by design approach. The partnership will serve as a platform for aligning national and regional manufacturing technology initiatives. Strategic cooperation with key actors will be developed to ensure take-up of research results.

Europe's manufacturing industry is strong in advanced manufacturing technologies, with the highest share of world patent applications and the highest number of venture capitalist backed firms. With 28.5 million people employed in almost 2 million enterprises, out of which 99.2% are SMEs, EU27 has 22% of the world's manufacturing output, yielding a trade surplus in manufactured goods of €421 billion annually. Deploying new green and digital technologies is necessary to foster the growth of Europe's manufacturing sector.

Processes4Planet (P4P)

Processes4Planet is the successor to the EU SPIRE Partnership. SPIRE is the European Association managing and implementing the Processes4Planet Public-Private Partnership. P4P aims to develop and foster the deployment of climate-neutral solutions for the European process industries to close the energy and feedstock loops. It will foster European global leadership in climate neutral and circular solutions, accelerating innovation and unlocking public and private investments.

Energy-intensive industries face many challenges to move towards commercially viable climate neutral and circular industrial solutions and foster the creation of new skills and jobs. With a total budget of €2.6 million, the P4P partnership will bring together process industries (cement, ceramics, chemicals, engineering, minerals and ores, non-ferrous metals, steel and water sectors), SMEs, the public sector, research centres and academia. The partnership will develop Hubs4Circularities (H4C) and first-of-a-kind, lighthouse demonstrator plants of (near) commercial size.

European Manufacturing Challenged by International Competition and Environmental Impact

Europe is home to a competitive, wealth-generating manufacturing industry and of extremely comprehensive manufacturing ecosystems which accommodates complete manufacturing supply chains. Europe's manufacturing industry is the backbone of the European economy, bringing prosperity and employment to citizens in all regions of Europe. The EU is a global market leader for high-quality products, and European Industry is the world's biggest exporter of manufactured goods. Manufactured goods represent 83% of EU exports. Thanks to the strengths of its manufacturing industry, the EU annually achieves a considerable trade surplus in the trade of manufacturing goods, which accounts for 286 billion euro in 20181. This healthy surplus generated by the manufacturing industry allows the EU to finance the purchase of other, non-manufactured goods and services, such as raw materials, energy (oil and gas), and services. The surplus in manufactured goods thus compensates the deficits which are generated by purchasing non-manufactured goods. However, the surplus generated by EU's manufacturing sector cannot fully compensate these deficits anymore: the overall EU trade balance (counting both manufactured goods and non-manufactured goods) changed from a surplus of 22 billion EUR in 2017 to a deficit of 25 billion EUR in 2018. From a macro-economic perspective, this is not a healthy

situation in the long run, and shows the importance of a strong manufacturing industry.

Although Europe's industry is a world-wide technology leader in most manufacturing market segments, this position is constantly being challenged by international competitors. While being highly competitive, statistics show that the EU manufacturing industry constantly needs to keep up with international competition. Competitors, especially from Asian economies, have reached advanced levels, often supported by state-supported programmes.

Furthermore, industrial structures are changing with significant foreign investments, including those by emerging economies, in Europe and in the US. And finally, such as large scale digitalisation, changes in trade rules and global environmental concerns create new challenges (Stolwijk et al. 2017).

European industry is also driving the transformation to climate neutrality and sustainable circular economy. While faced with increasing international competition, European manufacturing companies are at the same time in the process of constantly becoming "more productive with less," both in terms of material usage and energy consumption. The manufacturing industry is in a key position to enable the transformation to truly circular business models and the production of new environmentally friendly products in existing or emerging value chains. For 'true' circularity and zero-waste much has to be done, as illustrated by the graph below. Although the process has started, the speed of change needs to increase. The need to achieve circularity and minimal environmental impact implies radical innovations in manufacturing and related value chains to produce future green products.

Europe's manufacturing industries' vision for 2030 is to reinforce its global position in terms of competitiveness, productivity, and technology leadership2. The goal is to increase the number and attractiveness of jobs, while at the same time securing the environmental, economic and social sustainability for future generations in Europe. While global competition is increasingly challenging, Europe will reinforce its position because of its technological leadership and capacity to handle complexity and to fully embrace digital technologies which in return provide the basis to increasing services around manufacturing and along the product lifecycle.

Europe will specialise in the engineering of complex and highly interconnected value creation processes and systems. Its experience, creativity and unique tradition and identity will support the consolidation of European manufacturing. In 2030, the European manufacturing industry will be delivering excellent solutions, ensuring individual user-satisfaction (including

customised products and services), high quality and environmental and social sustainability. Europe will be the leader in manufacture engineering for highly personalised and complex products and services in a broad range of sectors, including aeronautics, automotive, production equipment, renewable energies, space and defence, and customer goods.

In 2030, Europe will be at the forefront of resource efficiency and circular economy implementation, which will contribute to its competitiveness at the global level and support its environmental sustainability. Manufacturing systems in Europe will be flexible and resilient, with optimal balance and integration between humans and machines. The European workforce will develop new skills to be prepared to address these challenges. Europe will be the leading "solution provider" in production technology, digitalisation, resource efficiency and circular economy implementation, which can only be achieved through the continuous development and exploitation of new technologies. Research and innovation will promote industrial digital transformation and thus enhance the competitive strengths of European companies, products, production systems, and services.

Specific Objectives - Made in Europe Partnership

Specific Objective 1: Efficient, Responsive and Smart Factories and Supply Chains

Made in Europe aims to contribute to more efficient, responsive and smart factories and supply chains (European Partnerships, 2021). Efficient and responsive production combines speed, precision, quality and reliability with flexibility and agility. Manufacturing companies need to produce from very small lot-sizes to big volumes and there is a growing need for the ability to quickly scale up from small to big lot-sizes whilst retaining the required quality in zero-defect and first-time- right production. Made in Europe will provide technologies and methods for zero-defect and zero-downtime high-precision manufacturing, including predictive quality and non- destructive inspection methods. It will also contribute to technologies for scalable, reconfigurable and flexible first-time-right manufacturing.

The manufacturing industry needs to respond quickly to market disruptions, changing customer demands, fluctuating characteristics of raw materials and components, and advanced emerging technologies that can be potential differentiators. Simultaneously, the manufacturing industry needs to increase quality and efficiency and reduce Total Cost of Ownership. Hence, upgradable and robust manufacturing systems and plants are necessary for

flexible, responsive and resilient manufacturing. Here, Artificial Intelligence, advanced robotics and other digital technologies will help. Therefore, Made in Europe will drive research in AI for manufacturing that is geared towards concrete applications based on context-dependent data collection, and assurance of data quality.

Products are increasingly complex with increasing amount of electronics or micro-features and advanced (multi-)materials. Products are also becoming smarter, stronger, lighter and more miniaturised and functionally integrated whilst remaining safe and secure. Completely new solutions will be introduced when designing future sustainable products enabling durability, energy-saving, the replacement of scarce or hazardous materials. Manufacturing system capabilities need to follow product and material roadmaps to enable the viable and sustainable manufacturing of these high-tech products. Made in Europe will contribute with advanced manufacturing processes to a new smart and complex products and solutions. Made in Europe will enhance parallel product and manufacturing engineering and the design for end-of-life/re-use/recycling, which contributes to sustainable products, services and manufacturing networks.

Highly complex, low volume products are mostly manufactured in (regional) ecosystems with a large number of SME first- and second-tier suppliers for world-class OEMs. Such ecosystems require data spaces with standardised data formats for the exchange of design, manufacturing, logistics and other data. Made in Europe will contribute to "responsive value chains" by studying advanced data spaces to support smart factories sharing data with other organisations.

Specific Objective 2:
Circular Products and Climate-Neutral Manufacturing

Made in Europe aims at ultra-efficient, low energy, circular and carbon-neutral manufacturing. Made in Europe will exploit the possibilities offered by advanced materials, digital technologies and manufacturing technologies to achieve a considerable reduction of the ecological impact and CO2-emissions. On an ecosystem level, recycling and re-use of materials and components will be increased while still raising the performance of the manufactured products.

With higher expected CO_2 prices and scarcity of key materials, the economics of manufacturing and materials use and re-use will change. This will have an impact on manufacturing technologies and will require new, different manufacturing equipment. Hence, Made in Europe will study advanced de-manufacturing, re-manufacturing and recycling technologies for

a circular economy involving manufacturing with new and substitute materials. Resource-efficient or circular approach necessitates the understanding of material flows and cooperation among organisations along the life-cycle and across sectors. This will require appropriate metrics and parameters which allow optimisation along the life-cycle. Circular- by-design approach needs to be applied including virtual end-to-end life-cycle engineering and manufacturing from product to production lines, factories, and networks. Moreover, digital platforms and data sharing solutions are needed to enable the management of circular product and production-systems life-cycles.

Specific Objective 3: New Integrated Business, Product-Service and Production Approaches; New Use Models

The service component of the revenues generated by products, in particular B2B products, continues to increase. Made in Europe will couple more tightly the design, manufacturing and (re-)configuration of products with the services that are associated to these products, considering also that these services evolve along the lifecycle of these products. In this context, product-service systems can be manufacturing systems that enable excellence and flexibility in future manufacturing, as well as high-value systems in areas such as mobility, energy, and health. Designing and engineering product-services, with growing amounts and value of software, requires interaction between many stakeholders from both the user- and supplier-side. Hence, the need for collaborative and digitalised ecosystems increases.

The increasing complexity of products, growing sustainability requirements, and the increasing innovation rate require that product design and engineering are carried out in parallel with manufacturing system engineering and configuration. In this context, the notion of Digital Twinning plays a role, where for each product design and each manufactured product a virtual/digital representation is maintained. Made in Europe will develop new technologies and methods for collaborative product-service engineering and manufacturing for customer-driven value networks.

In the future, efficient and smart factories can fully offer and deploy their capabilities in dynamic and sustainable manufacturing ecosystems where digitalisation delivers new ways to interact with customers, consumers, and users. Made in Europe will contribute to making this a reality, and will define approaches for implementing manufacturing processes that are closer to customers or consumers (urban manufacturing). While products become more and more customised, the end-to-end integration of manufacturing networks

is important, including logistics, which is a critical factor for unleashing the potential of very flexible distributed production. Made in Europe will develop technologies and methods to enable dynamic and sustainable value networks by the continuous and secure integration of digital technologies (5G, distributed ledgers, AI, etc.) into legacy approaches, supporting hardware and software lifecycle optimisation of products and manufacturing systems. This will lead to transparency, trust, and data integrity along the product and manufacturing lifecycle.

Specific Objective 4: Human-Centred and Human-Driven Manufacturing Innovation

Humans are at the core of the innovation process, increasingly supported by data analytics and decision support systems. Innovation is a process where different processes and disciplines (technological and non-technological) converge into concrete solutions and implementations. Made in Europe will develop new approaches and tools (including strategy management) that strengthen the capability of industrial actors to draw value from external sources of creativity, including start-up companies.

Design and development of advanced technologies will consider the role of the workforce at the earliest stages and will consider the available or required additional skills of the people involved. The full benefit of new tools based on advanced technologies can only be achieved by designing new work practices and by involving employees in the co-design. It is, for instance, of great importance to investigate how human knowledge and skills can complement Artificial Intelligence solutions and how smooth human-AI or human-robot interaction can take place. Made in Europe will improve human-device interaction using augmented and virtual reality and digital twins. It will also study human-technology complementarity in achieving excellence in manufacturing. The implementation of innovative solutions is often subject to reluctance, either associated with potential failure or because decision-makers and/or the workforce are faced with the unknown. Change management approaches are required to provide clear insights into the risks and benefits that are associated with change while involving all stakeholders in the process. This should also be associated with anticipating the required skills. Intelligent technologies will need to adapt to their users, while also addressing privacy and understanding workers. It is also important to empower and engage workers to co-design future tools and work practices, and to consider personal preferences in the process of manufacturing innovation and change

management. Made in Europe will define such change management approaches.

Smart Industry Strategy in China: Made in China 2025

In May 2015, the Chinese government formally announced its "Made in China 2025" strategy. Since then, this has emerged as a major focus and a daily topic of discussion across the country's entire manufacturing community as well as among officials at all China's Smart Manufacturing levels of government. Government and industry have also organized numerous seminars and workshops related to implementing smart manufacturing to help the Made in China 2025 strategy succeed. All this activity has significantly increased interest in technologies for smart manufacturing.

"Made in China 2025," a ten-year national plan, is intended to transform China from a big manufacturing country, to a strong one. It's the first action plan that focuses on promoting manufacturing in the country. Since this strategic plan was released, China's MIIT (Ministry of Industry and Information Technology) has issued a series of guidelines. The main manufacturing regions and industrial sectors have also released their own detailed plans to follow up on this national plan (Wübbeke et al. 2016). ARC anticipates that the central government will issue its latest guidelines on smart manufacturing planning sometime this month (December 2016). To encourage smart manufacturing applications, MIIT launched 46 funded Smart Manufacturing Pilot Projects in 2015, and another 64 projects in 2016. These projects all fall within five main categories:

- Discrete manufacturing.
- Process manufacturing.
- Network-based collaborative manufacturing.
- Mass-customized manufacturing.
- Remote operations and maintenance.

Pioneering Smart Manufacturing Applications in China. Today, more manufacturers have become involved, and more advanced applications are being planned, if not already implemented. Some relevant examples are described below:

- State-owned Sinopec, one of the world's largest oil refiners and a major ethylene supplier, began to plan smart manufacturing upgrades about five years ago. In 2013, the company chose four plants for smart manufacturing pilot projects: Jiujiang, Zhenghai, Yanshan, and Maoming. Among these, Jiujiang plant was listed as a MIIT Smart Manufacturing Pilot Project in 2015, and Zhenghai plant was listed as a MIIT Smart Manufacturing Pilot Project in 2016.
- IIoT Enables Digital Services. SANY is China's largest construction machinery supplier and the fifth largest in the world. This company began implementing M2M and IIoT applications almost 10 years ago. Today, more than 200,000 pieces of SANY-brand construction equipment are in operation around the world. The company has installed sensors and communication modules in each piece of equipment. These enable asset data to be transferred to an enterprise-level, customer service platform developed by SANY. Based on these data, the company can monitor the location and status of equipment in real time and perform predictive maintenance. SANY leverages this system to enhance customer service, improve product development, and support its sales and marketing activities.
- Haier is a leading global supplier of household electrical appliances. The company's main products include air conditioners, refrigerators, washing machines, and water heaters. Haier's core concept for its smart manufacturing solutions is "connected factory." The company defines this as an integrated, customer-oriented ecosystem encompassing the factory, machines, products, and customers. Haier builds its connected factories based on two dimensions, vertical and horizontal. Vertically, connected factories can improve customer value by meeting their specific requirements. When customers enter their requirements into the interactive platform, the manufacturing execution system automatically schedules production to enable the factory to quickly produce those customized products. At the same time, customers can check the production status of their products from their smartphones (metrology news, 2021).

Smart Technologies/Solutions for Sustainable Smart Factories

European Actions under the cluster 4 Digital, Industry and Space will support key enabling technologies that are strategically important for Europe's

industrial future, and deliver on the following six expected impacts in the Strategic Plan, through matching destinations in this Work Programme:

- Global leadership in clean and climate-neutral industrial value chains, circular economy and climate-neutral digital systems and infrastructures (networks, data centres), through innovative production and manufacturing processes and their digitisation, new business models, sustainable-by-design advanced materials and technologies enabling the switch to decarbonisation in all major emitting industrial sectors, including green digital technologies.
- Industrial leadership and increased autonomy in key strategic value chains with security of supply in raw materials, achieved through breakthrough technologies in areas of industrial alliances, dynamic industrial innovation ecosystems and advanced solutions for substitution, resource and energy efficiency, effective reuse and recycling and clean primary production of raw materials, including critical raw materials and leadership in circular economy.
- Sovereignty in digital technologies and in future emerging enabling technologies by strengthening European capacities in key parts of digital and future supply chains, allowing agile responses to urgent needs, and by investing in early discovery and industrial uptake of new technologies.
- Globally attractive, secure and dynamic data-agile economy by developing and enabling the uptake of the next-generation computing and data technologies and infrastructures (including space infrastructure and data), enabling the European single market for data with the corresponding data spaces and a trustworthy artificial intelligence ecosystem.
- Open strategic autonomy in conceiving, developing, deploying and using global space-based infrastructures, services, applications and data, including by reinforcing the EU's independent capacity to access space, securing the autonomy of supply for critical technologies and equipment, and fostering the EU's space sector competitiveness.
- A human-centred and ethical development of digital and industrial technologies, through a two-way engagement in the development of technologies, empowering end-users and workers, and supporting social innovation.

Key challenges identified in the sector Factories of the Future are (European Union, 2013):

A. Manufacturing the products future: Addressing the ever-changing needs of society and presenting the potential to open new market.
B. Economic sustainability of manufacturing: By combining high performance and quality with cost-effective efficiency, realizing reconfigurable, adaptable and developing factories capable of producing small scale economically.
C. Social sustainability of manufacturing: Integrating human skills with technology.
D. Environmental sustainability of production: Reducing resource consumption and waste production.

The following innovative solutions/technologies have been identified as key in the smart factories market according priorities identified by the European Commission in Cluster 5 of Horizon Europe Programme (markets and markets, 2021):

1. Green, flexible and advanced manufacturing
    - AI enhanced robotics systems for smart manufacturing (AI, Data and Robotics - Made in Europe Partnerships).
    - Zero-defect manufacturing towards zero-waste.
    - Laser-based technologies for green manufacturing.
    - Manufacturing technologies for bio-based materials.
2. Advanced digital technologies for manufacturing
    - Artificial Intelligence for sustainable, agile manufacturing (AI, Data and Robotics - Made in Europe Partnerships).
    - Data-driven Distributed Industrial Environments (Made in Europe Partnership).
3. Climate neutral, circularity of resources in the process industries, including waste and CO_2/CO
    - Deploying industrial-urban symbiosis solutions for the utilization of energy, water, industrial waste and by-products at regional scale (Processes4Planet Partnership).
    - Plastic waste as a circular carbon feedstock for industry (Processes4Planet Partnership).

- Reducing environmental footprint, improving circularity in extractive and processing value chains.
- Rapid reconfigurable production process chains (Made in Europe Partnership).
- Digital tools to support the engineering of a Circular Economy.
- Circular flows for solid waste in urban environment.
- Valorisation of CO/CO2 streams into added-value products of market interest.

4. Integration of Renewables and Electrification in process industry
   - Design and optimisation of energy flexible industrial processes (Processes4Planet Partnership).
   - Integration of hydrogen for replacing fossil fuels in industrial applications.
5. Increased autonomy in key strategic value chains for resilient industry
   - Paving the way to an increased share of recycled plastics in added value products.
   - Safe- and sustainable-by-design polymeric materials.
   - Safe- and sustainable-by-design metallic coatings and engineered surfaces.
   - Development of more energy efficient electrically heated catalytic reactors.
   - Creation of an innovation community for solar fuels and chemicals.
   - Advanced materials for hydrogen storage.
   - Antimicrobial, Antiviral and Antifungal Nano-coatings.

Results

In this chapter, after analyzing the R&D strategies and priorities in Europe and China, we have studied the example of the Valencian Region cluster of energy taking a sample of the companies associated to that cluster.

A total of 17 member companies had been analyzed. All the information come from their websites, brochure and all public available resources from any of that companies. The field work was done from August until October, 2021.

Find attached the result of the climate-neutral and smart cities, smart factories and smart ports, analyzing the CECV capabilities map. This material

plays an important role for international players to understand the technology companies that they can cooperate with in our region, and it can be used as a promotional material to improve visibility of their capabilities in the international markets.

Their Promotion in the Chinese Market

This capability maps had been shown to main players in the Energy and Industry 4.0, in the Chinese provinces of Hainan and Guangdong (China). The interest in our companies had, as a consequence, the organization of three different forums where all companies had been invited to discuss about potential bilateral cooperation projects.

The results showed that it is more convenient when Chinese institutions have direct access to the cluster, and the information of all members is well organized and explained using a capability map. The international potential partners are more open to establish relationships to know each other when they have direct contact with the cluster. The cluster director plays a very important role when the Chinese culture value the confidence of all stakeholders involved in a potential business relation between Chinese and Spanish companies.

In today's highly competitive and dynamic globalised markets, developing strategic orientations (market and entrepreneurial) in a network context helps build an optimal antecedent interfirm environment. In that context the cluster plays a key role in that network and strength the confidence values benefiting the potential business between all network members. This environment channels values generated through joint efforts to strengthen an individual cluster member's international performance (Irun et al. 2020).

Capabilities play an essential mediating role to achieve this effect through the integrated application of dynamic capabilities and ambidexterity theories. The cluster is a good example joining both characteristics explained in ambidexterity theories: on one hand, exploratory (adaptation and absorption) capabilities will influence the capacity to exploit knowledge through innovation capability and lead to higher performance. On the other hand, simultaneously highlights the need to classify each capability according to exploitative objectives. Taking into account the role of clusters and their function in exploratory and exploitative to contribute the achievement of their objectives, are in line with ambidexterity theory (Monferrer et al. 2021).

Table 1. Results of the climate-neutral and smart cities analyzing the CECV capabilities map

Enterprises	Code	Climate-Neutral and smart cities: Strategic Challenges					
		Digital Solutions for urban governance and citizen leadership (ICT urban platforms, IA, IoT, urban digital twins, cybersecurity, 5G communications)	Sustainable Buildings and Energy Efficiency (smart lighting, new materials, EERR integration)	Smart and Green Mobility (electric mobility, bio-fuels, smartgrids)	Renewable Energies (solar, wind, green and bio-hydrogen, ocean, biomass)	Circular Economy Urban waste and water management	Bioeconomy (biogas, bio-methane, bio-fuels production)
Enusa	E,L		X	X	X	X	
Iberdrola	U		X	X	X		
Iberapa	M,E		X	X	X		
ITE	RTD		X	X	X	X	
Inderen	M,E				X	X	X
Ingelia	T,E					X	X
Genia Global Energy	E,T		X	X	X	X	X
GDES	E		X		X	X	
Happÿdonia	I	X					
Nunsys	I	X				X	
Nutai	M,E	X		X			
Obremo	E		X		X		
GreenE	T,E					X	X
Tyris TV	ITS	X					
REE	O-electricity network operator			X	X		
Rotary Wave	T				X		

Table 2. Green and smart ports: CECV capabilities map

Enterprises	Code	Climate-Neutral and smart ports: Strategic Challenges 2021-2027			
		Logistical efficiency in infrastructure, operations or service delivery	Environmental sustainability and energy	Security and protection	Digitalization of processes and smart platforms
Iberdrola	U	X	X	X	X
Iberapa	E,M		X		
ITE	RTD	X	X	X	X
ECS	M		X		
Inderen	E,M		X		
Ingelia	T,E		X		
Genia Global	E,T		X		
Nunsys	I	X		X	X
Nutai	M,E	X	X		X
Obremo	E		X		
Rotary Wave	T		X		
Tyris AI	I	X			X

Table 3. Smart industry and smart factories: CECV capabilities map

Enterprises	Code	Smart factories: Strategic Challenges 2021-2027				
		Green, flexible and advanced manufacturing (smart manufacturing, zero waste)	Advanced digital technologies for manufacturing (AI for agile manufacturing)	Circularity of resources in the process industries, including waste and CO2/CO	Energy Efficiency and Integration of Renewables (in particular Hydrogen) and Electrification in Industry Process	Increased Strategic Value Chains for Resilient Industry (circular value chains and sustainable materials, circularity of composite materials)
Iberapa	E,M				X	
Iberdrola	U				X	
ITE	RTD	X	X	X	X	X
Enusa	E,L			X	X	
ECS	M				X	
Inderen	E,M			X	X	
Genia Global Energy	E,T			X	X	X
GreenE	E,T			X	X	X
Xabet	T,I	X	X		X	
GDES	E,T				X	
Nunsys	I	X	X	X	X	X
Obremo	E				X	
Omnielectric	S	X			X	
SicTech	T,M			X	X	
Titania	T	X			X	X
Tyris AI	T,I	X	X			
UBE	T			X		X

Conclusion

Clusters as innovation ecosystems and their role in analyzing the capabilities of member companies as well as disseminating them, with the objective of the international promotion of their members, specifically in the Chinese market.

As a consequence of our work, we can explain the convenience of private companies in being part of an association to benefit both from the information generated by the cluster to which it belongs (which will contribute to improvements in the field of innovation); enough to be able to exploit all that knowledge acquired in the development of new projects aimed at new international markets.

Each member company of the cluster is a private company with its own objectives, but it will benefit from belonging to the cluster of the network of contacts and the ecosystem generated by the cluster, especially in access to the Chinese market. A distant, complex, dynamic market that especially values the role of an institution such as the cluster to strengthen trust among all the companies that are going to undertake an international project in the area of Energy and Industry 4.0.

On the other hand, and following the ambidexterity theory, member companies will benefit from access to the Chinese market by:

- Exploration:
  - Obtaining valuable information from the Chinese market, tailored to the needs of the energy sector and Industry 4.0; especially in the areas of opportunity that exist in smart cities, smart ports and smart factories.
  - Contacts in the areas of interest and belonging to a network with up-to-date information that already invests in the active maintenance of the network itself so that it can be used at the convenience of the members at the precise moment in which each company needs to activate prospecting of concrete opportunities for your company in China.
- Exploitation:
  - The data of the member companies analyzed and included in the study of their specific capacities to be able to participate in smart cities, smart ports and smart factories projects.
  - Dissemination of the generated capacity maps as well as basic information on each company to support their internationaliza-

tion, specifically for what is referred to in this study towards the Chinese market.

The role of European clusters as innovation ecosystems, and their implication in the successful international promotion of the membership companies is key, as we analyzed in this chapter. In the Chinese market described as a political economy where the Government plays a central role in the economy, private Chinese companies and institutions they feel more comfortable when a public association (such as European clusters), are involved in international programs with the objective of promoting bilateral cooperation programs that boost business activities between our countries.

Limitations and Future Lines of Research

In terms of limitations, we have only studied the capacities of the member companies of one cluster, specifically the Energy Cluster of the Valencia Region. As future lines of research, it is proposed to be able to extend the analysis and configuration of the capabilities map to other associations and clusters, in order to have organized information in maps, that favor greater visibility of its members towards promotion in international markets.

References

Chen, Y., Ardila, A., Frame, G. (2017). Achieving energy savings by intelligent transportation systems investments in the context of smart cities. *Transportation Research Part D*, 54, 381-396.

EDB Singapore (2021). *Singapore is world's smartest city for the third year*: IMD Smart City Index. https://www.edb.gov.sg/en/business-insights/insights/singapore-is-world-s-smartest-city-for-the-third-year-imd-smart-city-index.html.

European Commission (2020). *European Green Deal*. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en.

European Commission (EC): Proposed Mission: 100 Climate-neutral Cities by 2030 – by and for the Citizens. *Report of the Mission Board for climate-neutral and smart cities*. Publications Office of the European Union, Luxembourg (2020)

European Partnerships in Horizon Europe (2021). *Types of partnerships, how partnerships are being identified, candidates for partnerships, contact details, impact assessments*. https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-

programmes-and-open-calls/horizon-europe/european-partnerships-horizon-europe_en.

European Sea Ports Organisation. *Position Paper on the Commission's proposal on Port Reception Facilities (COM 2018/0012)*. https://www.espo.be/media/2018.05.09_PR_ESPO%20position%20paper%20on%20PRF.pdf.

European Commission, Directorate-General for Research and Innovation, (2013) Factories of the future : multi-annual roadmap for the contractual PPP under Horizon 2020. Publications Office. https://data.europa.eu/doi/10.2777/29815

European Commission. (2021). Mission Area: Climate-Neutral and Smart Cities. Foresight on Demand Brief in Support of the Horizon Europe Mission Board. Luxembourg: Publications Office of the European Union. doi:10.2777/123417. Retrieved from https://op.europa.eu/s/tD5Z.

Eurostat (2021). *Sustainable development in the European Union - Overview of progress towards the SDGs in an EU context*. https://ec.europa.eu/eurostat/documents/4031688/12878925/KS-03-21-097-EN-N.pdf/c7d90bf7-c3ae-00b5-7804-80526931036b?t=1623827181153.

EUSME (2018). *Smart Cities in China, Global Opportunities* Kirk Wilson.

Gheorghe, G. (2019). Challenges and research in the innovation of digital enterprise and smart industry (4.0). *International Conference on Hydraulics and Pneumatics - HERVEX* November 13-15, Băile Govora, Romania.

Irún, B, Monferrer, D, & Moliner, M.A (2021). The Energy and Industry 4.0 Sectors and their Opportunities in the Chinese Market. The Key Role of Clusters in the Current Context of Technology Transfer. In book: *Public-Private Partnerships: Trends, Perspectives and Opportunities*. Publisher: Nova Science Publishers.

Irún, B, Monferrer, D, & Moliner, M.A (2020). Network market orientation as a relational governance mechanism to public-private partnerships. *Journal of Business Research*, 121, 268-282.

Markets and Markets (2021). *Smart Factory Market With COVID-19 Impact by Component (Industrial Sensors, Industrial Robots, Industrial 3D Printers, Machine Vision Systems), Solution (SCADA, PAM, MES, Industrial Safety), Industry, and Region - Global Forecast to 2026*.

Metrology News (2021). 5G Implementation Breakthrough for Smart Manufacturing Announced in China.

Monferrer, D., Irún, B., Estrada, M., & Moliner, M.A. (2021). Network market and entrepreneurial orientations as facilitators of international performance in born globals. The mediating role of ambidextrous dynamic capabilities. *Journal of Business Research*, 137, 430-443.

Stolwijk, C., Punter, M. & Montalvo, C. (2017). Chapter 10: "Smart Industry' and the confluence of standards" In *Handbook of Innovation and Standards*. Edward Elgar Publishing.

United Nations (UN) *General Assembly (2015). 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs)*.

Wübbeke, J., Meissner, M., Max J. Zenglein, Ives, J., & Conrad, J. (2016). *Made in China 2025: The making of a high-tech superpower and consequences for industrial countries*. Merics, 2.

Chapter 5

Digitalization and Its Effect on the Gender Gap in the Technology Job Market

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Abstract

Jobs related to technology and engineering have traditionally been dominated by men and tend to be cited as paradigmatic examples of male-dominated fields, presenting women with barriers to access and putting obstacles in the way of their development. In this context, the aim of the present research is twofold. First, it seeks to analyse gender gaps in the technological sphere of the labour market through the use of three indicators: Employed ICT specialist, Employed persons with ICT education and Gender pay gap in the EU-27 countries during the period 2004-2020. The second objective is to identify whether Europe is moving in the same direction in terms of the labour market in the technology sector, by examining the convergence of employment indicators for the male and female population.

Analyses of beta and sigma convergence of digital employment indicators confirm that European countries are reducing disparities, such that countries which initially had less of their population employed in ICT have grown faster than the more advanced countries in this regard, thereby achieving greater equality between them. In the case of gender pay gaps, beta convergence is confirmed, again indicating that EU nations are following a homogeneous trend in this variable. However, sigma convergence of the wage gap is not confirmed; disparities in the wage gap increase over the analysed period.

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Introduction

Digitalization is accelerating changes in the labour market, putting the emphasis on flexibility in the form of temporary employment contracts and individually-customized services, as well as encouraging pluriactivity (Eichhorst et al., 2017). In recent years, there has been a strong demand for information and communication technology (ICT) professionals; however, there are few women working in this sector (Perifanou and Economics, 2020). The low representation of women is an issue in both technological education and jobs (Sainz et al., 2020), leading to a notable gender digital divide in the labour market.

In general terms, the Organization for Economic Co-operation and Development (OECD, 2001) defines the digital divide as the gap between individuals, households, and economic and geographical areas at different socioeconomic levels with regard to both their opportunities to access ICTs and to their use of the internet for a wide variety of activities. Drilling down further, Martin (2020) and Elena-bucea et al. (2021) make various distinctions regarding the differences in the level of digitalization according to geographical location, economic factor, level of education, knowledge of languages, age and gender. This research focuses on the gender digital divide, defined as the measure of the extent to which women lag behind men in incorporating the use of new technologies (de Andres et al., 2020).

According to Duran (2021), there is gender inequality in digital skills, and thus a need to implement training programmes targeted at the female population to strengthen their position in the labour market. The importance of reducing gender gaps in digital engagement lies in the economic benefits for women and in facilitating their labour market integration, increasing their power to play a part in designing technologies and accelerating the progress towards achieving the sustainable development goals (Sainz et al., 2020). There are different phases to the gender gap in digitalization: the first, which has already been overcome, refers to the use of a technological device to connect to the internet, where equality between the sexes has been achieved (Martinez-Cantos and Castaño, 2017; Suso, 2021). However, in the context of the labour market, the ICT and digital sectors pose specific impediments for women. Jobs related to technology and engineering have traditionally been

dominated by men, and tend to be cited as paradigmatic examples of male-dominated fields, presenting women with barriers to access and putting obstacles in the way of their development (Hari, 2016).

Against this backdrop, the aim of the present research is twofold. First, it seeks to analyse gender gaps in the technological sphere of the labour market through the use of three indicators: Employed ICT specialist (Employed ICTS), Employed persons with ICT education (Employed PICTE) and Gender pay gap in the EU-27 countries during the period 2004-2020. The second objective is to identify whether Europe is moving in the same direction in terms of the labour market in the technology sector, by examining the convergence of employment indicators for the male and female population. The analysis centres on three research questions:

Q1. Which EU countries have the widest gender gap in the technology job market?

The analysis is carried out by calculating the absolute and relative distances between the male and female population in the Employed ICTS and Employed PICTE indicators for the 27 EU countries. The value and the sign of these distances will provide an answer to the research question posed.

Q2. Has there been a reduction in the disparities among EU countries in digital-skills-related jobs segmented by gender?

The results of the estimation of beta and sigma convergence indicate the evolution of disparities among EU countries over the period 2004-2020 in the labour market indicators under study. Male and female employment are analysed separately, such that convergence may be detected in either or both of them.

Q3. Are EU countries converging in the gender pay gap in the ICT sector?

The pay gap is another issue in the technology sector accentuating the differences among the population. An analysis is conducted of the trends in disparities among EU countries during the period 2008-2020.1 It can thus be checked whether European countries are moving towards a more

[1] The analysed period differs from that for the Employed ICTS and Employed PICTE indicators, due to the availability of data in Eurostat.

homogeneous pay gap, by calculating the beta and sigma convergence among them.

The study of gender differences and convergence in the field of digitalization is a line of research that has recently been gaining in importance due to the development of new technologies in all social areas. Most of the studies published to date focus on internet access and digital skills (Martin-Cantos, 2013; Ragnedda and Kreitem, 2018; Arroyo, 2020; Grześkowiak, 2020; Vasilescu et al., 2020; Lopez-Martinez et al., 2021; van Kessel et al., 2021). Others have analysed the gender pay gap in relation to different sectors or countries (Boll and Lagemann, 2019; Lausi et al., 2021). Unlike the aforementioned literature, this research focuses on the convergence of employment indicators for the technology sector, offering a view of gender inequality in the job market and indicating to the leaders of EU countries the direction their policies should take to achieve greater equality in Europe.

The rest of the chapter is structured as follows. Section 2 explains the methodology and sample used in the empirical analysis. Section 3 presents the results that answer the research questions raised. Lastly, section 4 summarizes the main conclusions.

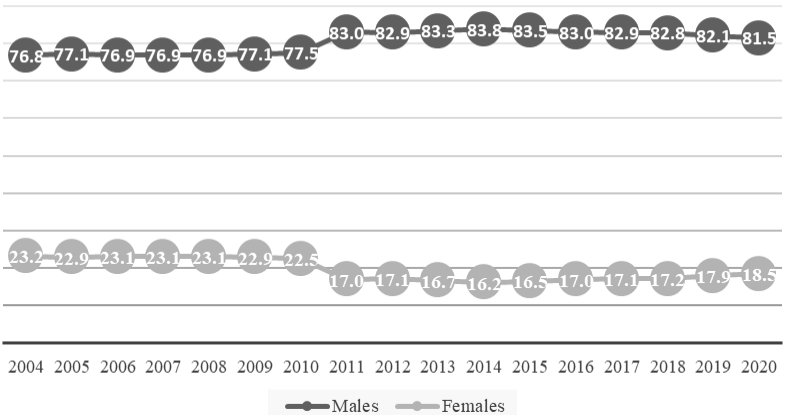
Methods and Materials

The study of the gender gap in employment in the technology sector focuses on two reference indicators (Employed ICTS and Employed PICTE), both of which are sourced from Eurostat's Digital Economy & Society database, specifically the Digital Skills area. On the other hand, the differences in wages between men and women are analysed using the Gender pay gap variable for the Information and Communication sector, taken from the Earnings area of Eurostat2 labour market statistics. The research sample is made up of the 27 EU countries and segmented into the male and female population aged 16-74 employed in the technology sector.

According to Lopez-Cobo et al. (2020) and the National Observatory of Technology and Society (2021) the variable Employed ICTS is defined as those individuals employed in tasks related to developing, maintaining and operating ICT systems and where ICTs are the main part of their job. The incorporation of ICTs into all economic activities has meant that ICT

[2] https://ec.europa.eu/eurostat/databrowser/view/earn_gr_gpgr2/default/table?lang=en.

specialists are engaged in a variety of activities, not just in the technology sector (Segovia-Perez et al., 2020).



Source: Eurostat.

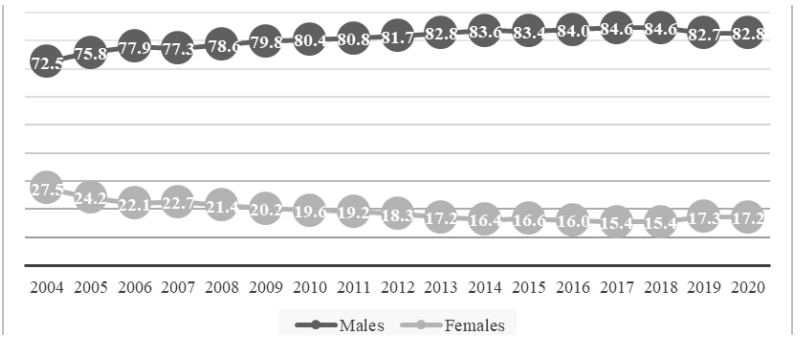
Figure 1. Evolution of the percentage of male and female Employed ICTS for the EU-27 as a whole.

In the EU-27 as a whole, Eurostat data show that ICT specialists represented 4.3% of the total workforce in 2021, with this indicator displaying a rising trend. The countries showing the greatest predominance of such specialists belong to the Nordic-Baltic region: Finland with 7.6%, Sweden with 7.5% and Estonia with 6.5%. On the other hand, statistics show the existence of a gender gap in Employed ICTS of more than 50 percentage points (pp), with a slightly increasing trend in recent years. In 2020, approximately 9 out of 10 ICT specialists were men (Figure 1).

The indicator Employed PICTE covers those employed in the technology sector who have higher education studies related to Computer use, Database and network design and administration, and Software and applications development and analysis. According to Eurostat statistics, there is a marked gap between the proportion of ICT-educated male and female workers in terms of the EU-27 average, and this gap has been growing in the period analysed (Figure 2). Specifically, in 2004, out of every 7 people hired 5 were men, whereas by 2020 this figure had risen to 5.7 men.

Krchová and Švejnová (2021) claim that in many developed economies there is still a notable gender gap in access to, use of and ownership of digital technologies, meaning the benefits of digital technologies are not shared

equally by everyone. Furthermore, the digital transformation is fundamentally changing the content and the nature of jobs, and the skills needed to do them. All this can be confirmed with the analysed indicators (Employed ICTS and Employed PICTE).



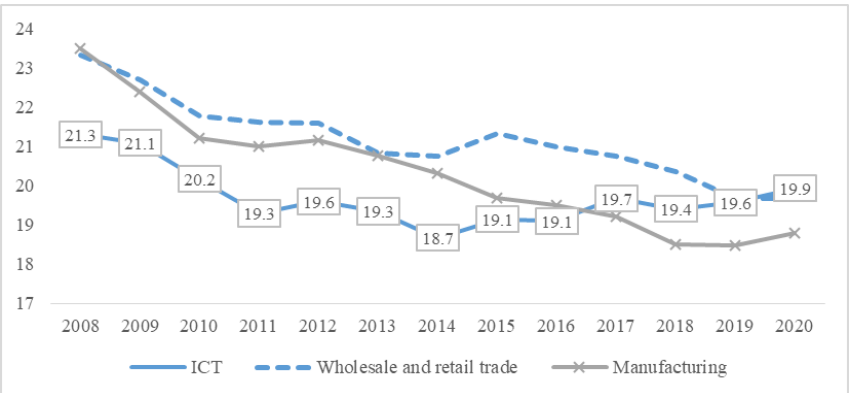
Source: Eurostat.

Figure 2. Evolution of the percentage of male and female Employed PICTE for the EU-27 as a whole.

On the other hand, the variable Gender pay gap measures the difference between the average gross hourly earnings of male and female paid employees. It is calculated using the following equation (Eurostat, 2018):

$$\frac{\text{Mean(gross)hourly earnings of men} - \text{Mean(gross)hourly earnings of women}}{\text{Mean(gross)hourly earnings of men}} \quad (1)$$

Wage differentials are the result of many factors: one is "sectoral segregation by gender," defined as the concentration of one sex in certain economic activities; another possible cause is "occupational segregation by gender," which refers to certain jobs. In this regard, the International Labour Organization (2018) explains that the technology jobs held by women are concentrated in lower-paid activities such as ICT project managers or support jobs rather than others such as software development, which are considered better-paid jobs. Furthermore, Sánchez-Vidal (2016) indicates that a lack of self-confidence in one's skills, including technological skills, leads to a pay gap since women think that they are less worthy than their male colleagues. Nevertheless, Boll and Lagemann (2019) claim that a large part of the wage gap between men and women remains unexplained. This research uses the Gender pay gap indicator for the ICT sector in the period 2008-2020 (Figure 3).



Source: Eurostat.

Figure 3. Evolution of the mean EU-27 Gender pay gap.
Comparison of three sectors.

The evolution of the mean Gender pay gap in the ICT sector across the EU-27 is acceptable, since wage inequality between men and women drops from 21.3% to 19.9%, but there is still a long way to go to achieve greater equality. The sectors that have similar pay gaps to technology are manufacturing and trade, which also show a favourable evolution over the last 12 years (Figure 3).

The analysis of gender inequalities in Employed ICTS and Employed PICTE is carried out by calculating the distance between the participation of men (M) and women (W) in two ways, using the definition provided by the International Telecommunication Union (ITU, 2019) and subsequently applied in several studies (OECD, 2020; EIGE, 2020; Lopez-Martinez et al., 2021). First, the gender gap is calculated in absolute terms (M-W) expressed in pp, and second, in relative terms (M-W)/W expressed as a percentage. In both cases, the resulting value can be negative, if women are in the majority, while the value will be positive value if men are in the majority.

Another point of interest is the study of the convergence of the indicators Employed ICTS, Employed PICTE and Gender pay gap. Calculating the convergence reveals how disparities among the EU-27 countries in these variables increase or decrease. The technique applied is the calculation of beta and sigma convergence, based on Solow's (1956) neoclassical growth model. This model suggests that if countries differ only in their initial levels of capital and per capita income, the poorest tend to grow faster than the rich to reach the same long-term steady state. The literature contains studies that analyse

the speed of economic convergence using sigma and beta convergence (Sala-i-Martin, 1996; Petrakos and Saratsis, 2000; Azzoni, 2001; Miller and Genc, 2005). However, in recent years, they have also been applied in areas related to societal welfare, specifically health issues (Jaworska, 2014), the environment (Karakaya et al., 2019; Solarin, 2019; Abbassi and Haq, 2022), population structures (Krupowicz and Kuropka, 2022), human development (Biggeri and Ferrone, 2022), digitalization (Martínez-Cantos et al., 2020; Aleksejeva et al., 2021; Crespo and Uljas, 2021) and gender inequality (Gonzalez et al., 2019; Lopez-Martinez et al., 2021) among others. Along these lines, the present research applies this methodology to test for convergence among European countries in the participation of human resources in the digital sphere segmented by gender.

Beta convergence: confirms whether a country that starts with very low values in a given indicator achieves greater growth over time than other countries that were originally more advanced in this regard. Identifying this convergence requires estimating an equation proposed by Sala-i-Martin (1996), where the value of the indicator at the initial moment explains the average growth rates over a specific period for a set of countries.

$$\frac{1}{T} Ln\left(\frac{X_{it}}{X_{ij}}\right) = a + b \cdot Ln\left(X_{ij}\right) + \varepsilon_{i,t} \tag{2}$$

where Xi, t it is the variable under analysis (in this study, Employed ICTS, Employed PICTE or Gender pay gap); i is each of the EU-27 countries; t is the last year; j is the first year; T is the total number of years in the analysed period; and εi, t is the random disturbance.

A negative and significant result for the estimated coefficient (b) confirms beta convergence, whereas a positive results indicates the persistence of divergence. The parameter b is used to determine the speed of convergence through the calculation of β:

$$\beta = \frac{-\ln(1+b)}{T} \tag{3}$$

where T is the number of years analysed.

A positive value for the β coefficient indicates the occurrence of convergence (expressed as a percentage).

Sigma convergence: analyses the dispersion of a given indicator. In this case, convergence occurs if the standard deviation of a variable decreases over time. For sigma convergence to occur, beta convergence is a necessary but not a sufficient condition (Barro and Sala-i-Martin, 2004). Graphically depicted, the evolution of the standard deviation reveals whether there is a reduction in the dispersion of the analysed factor. In addition, from an analytical point of view and following Kurupka (2022), estimating equation (4) using ordinary least squares confirms whether the standard deviation decreases over the years.

$$\sigma_t = a + bt \tag{4}$$

where,

σ_t: standard deviation of the logarithm of the analysed indicator at time t
t: year to which the standard deviation refers

In this study, the standard deviation of the Naperian logarithm of Employed ICTS and Employed PICTE in the period 2004-2020 is calculated, as well as the Naperian logarithm of Gender pay gap in the period 2008-2020. The aim is to analyse whether European countries become more equal over time in terms of gender differences in the labour market.

Results

The female population represents 52% of the total in Europe, but only about 18.5% of women work in ICT-related jobs (Table 1). These inequalities demonstrate the existence of a gender gap in the labour market, pointing to the underrepresentation of women in the technology sector. In this vein and in line with the objectives of the study, we can answer the research questions raised.

Q1. Which EU countries have the widest gender gap in the technology job market?

Using the Employed ICTS indicator, the digital divide was calculated in absolute terms (M-W) and relative terms (M-W)/W for each EU-27 country (Table 1).

Table 1. Employed, 2020

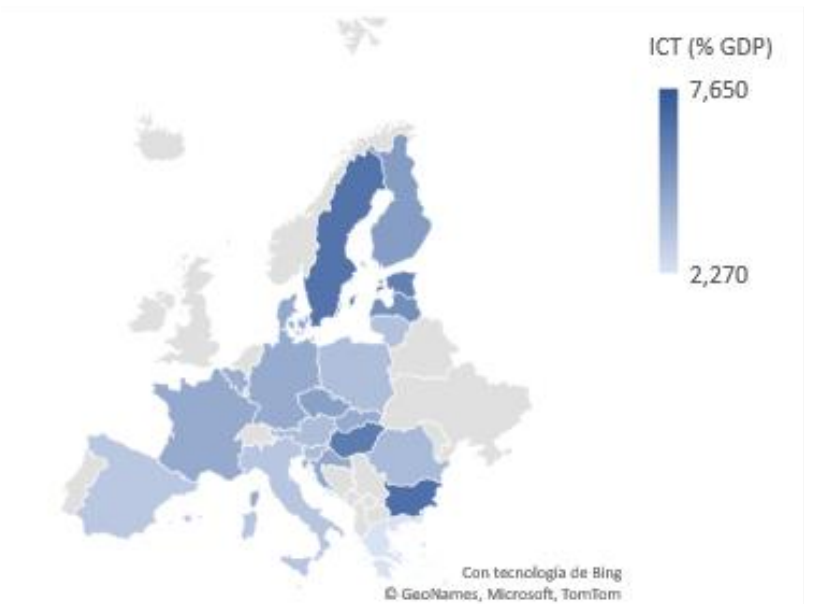
	Employed ICTS				Employed PICTE			
			Gender gap				Gender gap	
	Women (%)	Men (%)	M-W (pp)	(M-W)/ W (%)	Women (%)	Men (%)	M-W (pp)	(M-W)/ W (%)
EU-27	18.5	81.5	63	340.5	17.2	82.8	65.6	381.4
Czechia	10.3	89.7	79.4	770.9	11.1	88.9	77.8	700.9
Malta	10.7	89.3	78.6	734.6	15	85	70	466.7
Hungary	12.3	87.7	75.4	613.0	17.1	82.9	65.8	384.8
Poland	15	85	70	466.7	11.7	88.3	76.6	654.7
Italy	15.7	84.3	68.6	436.9	16.9	83.1	66.2	391.7
Slovakia	15.8	84.2	68.4	432.9	13.2	86.8	73.6	557.6
Slovenia	17.3	82.7	65.4	378.0	9.7	90.3	80.6	830.9
Belgium	17.4	82.6	65.2	374.7	10.9	89.1	78.2	717.4
Germany	17.5	82.5	65	371.4	14.8	85.2	70.4	475.7
Netherlands	17.6	82.4	64.8	368.2	13.9	86.1	72.2	519.4
Croatia	18.1	81.9	63.8	352.5	16.4	83.6	67.2	409.8
Cyprus	18.1	81.9	63.8	352.5	27.5	72.5	45	163.6
Spain	19.8	80.2	60.4	305.1	20.9	79.1	58.2	278.5
Luxembourg	19.8	80.2	60.4	305.1	13.5	86.5	73	540.7
France	20.1	79.9	59.8	297.5	16.6	83.4	66.8	402.4
Austria	20.3	79.7	59.4	292.6	14.5	85.5	71	489.7
Ireland	20.7	79.3	58.6	283.1	23.2	76.8	53.6	231.0
Sweden	21.3	78.7	57.4	269.5	24.5	75.5	51	208.2
Portugal	21.8	78.2	56.4	258.7	19	81	62	326.3
Estonia	22.1	77.9	55.8	252.5	18.1	81.9	63.8	352.5
Denmark	22.3	77.7	55.4	248.4	32.9	67.1	34.2	104.0
Latvia	22.9	77.1	54.2	236.7	24.8	93.6	68.8	277.4
Finland	23.3	76.7	53.4	229.2	14.1	85.9	71.8	509.2
Lithuania	23.6	76.4	52.8	223.7	20.7	79.3	58.6	283.1
Romania	26.2	73.8	47.6	181.7	27	73	46	170.4
Greece	26.5	73.5	47	177.4	30.6	69.4	38.8	126.8
Bulgaria	28.2	71.8	43.6	154.6	27.4	72.6	45.2	165.0

Source: Eurostat.

The positive sign in all cases attests to the higher levels of male employment than female employment in the area analysed. In turn, the values of inequalities in relative terms exceed 100% in all countries, yielding evidence of a much higher number of jobs held by men than by women. The distance between the two populations is not homogeneous across countries. The smallest differences are found in Bulgaria (43.6 pp), Greece (47 pp) and Romania (47.6 pp), which are countries where ICT specialists represent a fairly small share of total employment (below 3.5% in all cases). The greatest digital divides are found in Czechia (79.4 pp), Malta (78.6 pp) and Hungary

(75.4 pp) where the share of ICT specialists in their respective labour markets is around the EU mean (4.3%).

In the case of the variable Employed PICTE, the smallest inequality is recorded for Denmark (34.2 pp) and the largest for Slovenia (80.6 pp). It can therefore be seen that the jobs requiring ICT education are drivers of greater gender differences; specifically, in 16 countries the gap in Employed PICTE is wider than the gap in Employed ICTS. The statistics thus show that the EU has a long way to go in terms of equality. The current gaps must be reduced over time. For this to happen, both higher education institutions and companies linked to ICT have to establish strategies for generating more inclusive dynamics, improving hiring conditions and promoting equal opportunities in professional careers (Martinez-Cantos and Castaño, 2017). What is more, Larsson and Viitaoja (2020) point out, it is important to bring about changes in people's attitudes, behaviour and habits through information campaigns that show the relevance of the role of women in studies related to science and technology.



Source: Own elaboration and Eurostat.

Figure 4. ICT sector as a percentage of GDP (2019).

As can be seen in Figure 4, the countries whose technology sectors account for the highest shares of GDP are Malta (7.65%), Bulgaria (6.62%) and Switzerland (6.48%), while Spain and Greece register values below 3.5% (data from Eurostat, 2019). Nevertheless, the gender digital divide in employment does not show a significant relationship with the share of the ICT sector in the country's GDP. Indeed, countries with technology sectors that represent a similar share of their national production have a very different digital divide. For example, in Romania and Poland their ICT sectors represent 3.74% and 3.62% of their GDP, respectively, while their gender differences in Employed ICTS are 47.6 pp and 70 pp. In turn, Estonia, Sweden and Bulgaria register low levels in the digital divide (55.8 pp, 57.4 pp, 43.6 pp, respectively) and high percentages for the share of the ICT sector in GDP (5.98%, 6.48%, 6.62%). All this indicates that it is the policies aimed at promoting gender equality that reduce the problem of the digital divide rather than those that bring more investment into the ICT sector.

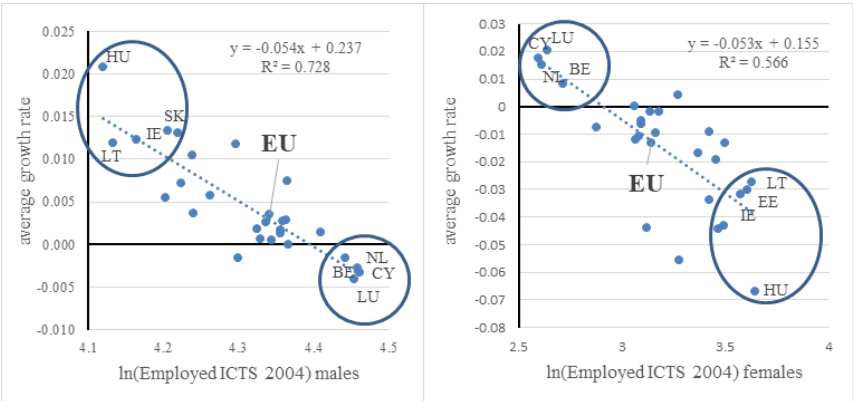
Q2. Has there been a reduction in the disparities among EU countries in digital-skills-related jobs segmented by gender?

The analysis of convergence examines whether the EU states are moving towards one another in terms of the proportion of male employees working in the technology sector, with a similar analysis then conducted for the female population. Thus, beta convergence occurs when the countries that are lagging the most (those starting with male or female population levels below the EU average) show greater growth than the more advanced countries. From an analytical point of view, the estimation of equation (2) by ordinary least squares identifies the possible existence of beta convergence if a negative relationship is found between the initial value of the variable and its growth rate in the male and female samples (Table 2).

Table 2. Results β-convergence

	b	β
Male sample		
Employed ICTS	-0.053***	0.32%
Employed PICTE	-0.041***	0.25%
Female sample		
Employed ICTS	-0.053***	0.32%
Employed PICTE	-0.034***	0.20%

Source: Own elaboration.



Source: Own elaboration.

Figure 5. β-convergence of Employed ICTS.

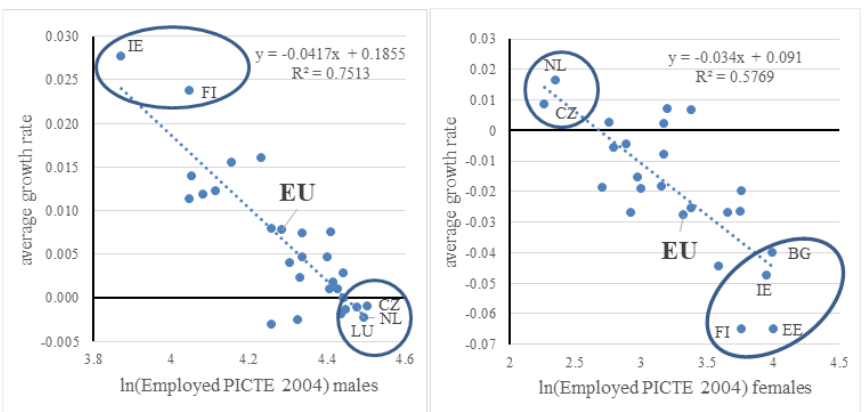
The results for both samples confirm the existence of convergence as indicated by the negative sign and significance of the b coefficient for both the Employed ICTS and Employed PICTE variables. Moreover, faster convergence is found for men as their estimated coefficient for Employed PICTE is larger (β = 0.25%). Figures 5 and 6 depict the relationship between the initial relative value of employment and the average annual growth rate for each European country, for both the male population (figures on the left) and the female population (figures on the right).

The negative slope of the trend line points to the existence of convergence in the Employed ICTS indicator in both populations. Furthermore, Figure 5 (right) shows that Hungary (HU), Lithuania (LT), Slovakia (SK) and Ireland (IE) are the places where there has been the greatest increase in Employed ICTS for men, and that initially presented the lowest values of the analysed variable. Conversely, Belgium (BE), Luxembourg (LU), Cyprus (CY) and the Netherlands (NL) have all registered reductions in Employed ICTS between 2004-2020, and were the countries registering the highest levels in 2004. The pattern displayed by these groups of countries is inverted in the female population, such that BE, LU, CY and NL are among the countries with the highest growth, while IE, LT and HU are among those with the highest initial values of employment.

In the EU as a whole, different growth patterns can be seen in the sample of men, with positive rates (0.34%), unlike women who show negative rates of change (-1.33%). All this reflects the increase in men being hired in the technology sector—for reasons of availability, more ICT education, and

higher salaries, among others—along with a corresponding decrease in women.

According to Figure 6, the negative trend line again reflects the existence of convergence among EU countries for the Employed PICTE indicator. Specifically, the countries that started out in 2004 with levels above the European average are those that show negative growth rates between 2004 and 2020 (located in the lower right quadrant). However, countries with lower values in 2004 show a sharper increase in the rate of change (upper left quadrant). Comparing the male and female samples for Employed PICTE, we again see the countries displaying opposite patterns of behaviour. In particular, Ireland (IE) and Finland (FI) show very high growth for the male segment but the corresponding rates for women are negative.



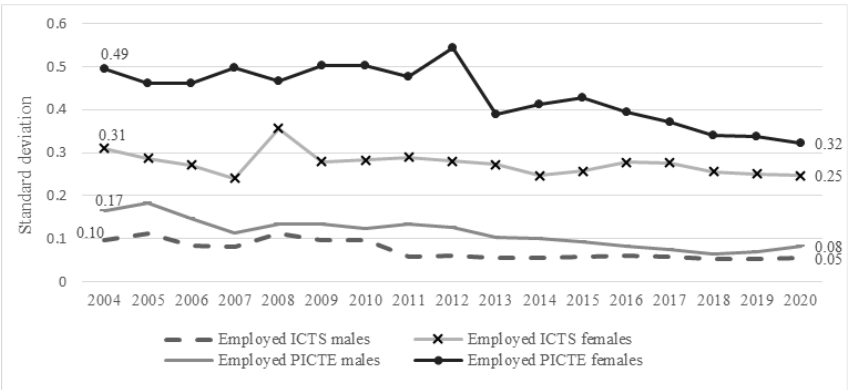
Source: Own elaboration.

Figure 6. β-convergence of Employed PICTE.

Table 3. Estimation of sigma convergence

	b
Male sample	
Employed ICTS	-0.003***
Employed PICTE	-0.006***
Female sample	
Employed ICTS	-0.002***
Employed PICTE	-0.010***

Source: Own elaboration.



Source: Own elaboration.

Figure 7. σ-convergence Employed ICTS and Employed PICTE (males and females).

On the other hand, we analyse the sigma convergence, interpreted as the dispersion among countries for a given indicator over a period. The estimation of equation (4) yields the estimated parameters for the employment variables under study in each of the samples separated by gender (Table 3).

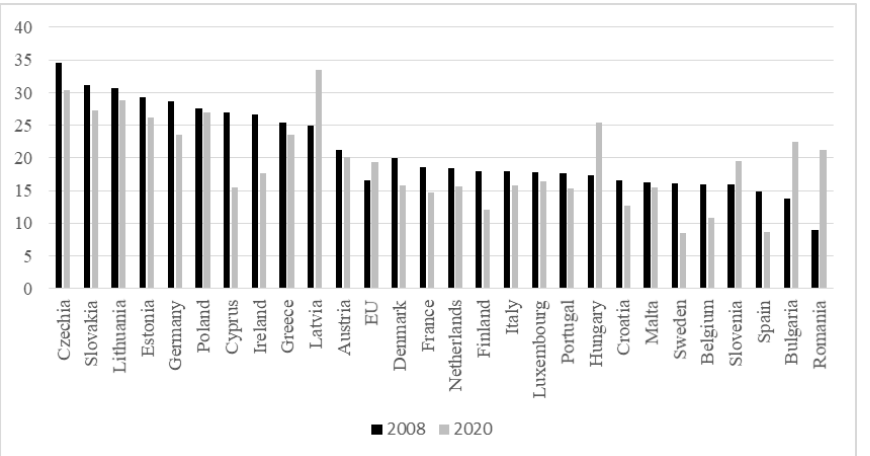
In the period 2004-2020, the existence of sigma convergence was confirmed by all the negative and significant coefficients estimated (Table 3). Therefore, the dispersion among the EU-27 countries in people employed for their digital skills has been decreasing (for Employed ICTS, 19.35% in women and 50% in men; for Employed PICTE, 34.7% for women and 52.9% in men), slightly more so for the female population (Figure 7).

The results of sigma and beta convergence confirm the existence of convergence among European countries in the digital skills employment indicator for both samples, meaning Q2 can be answered in the affirmative. This suggests that national policies are bringing countries closer together in terms of digital jobs in European countries.

Q3. Are the EU countries converging in the gender pay gap in the ICT sector?

The analysis of convergence of the Gender pay gap indicator in the technology sector in the period 2008-2020 examines whether EU countries tend towards homogeneous behaviour in differences in employee pay. First, we describe the change in inequality between the first and last year of the study

by country (Figure 8). This identifies the countries whose policies are helping to reduce the gap in the price of labour.



Source: Own elaboration.

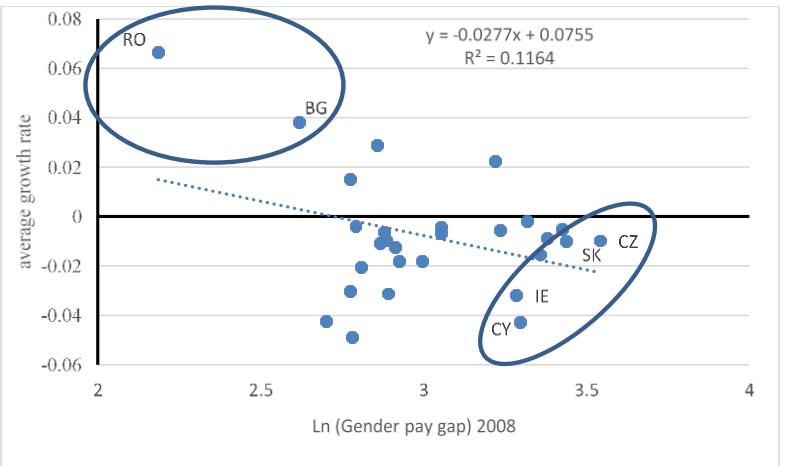
Figure 8. Gender pay gap in the ICT sector.

The situation of women will improve in those countries that have managed to narrow the pay gap over time. According to Eurostat, in the EU as a whole there is marked inequality in the technology sector; specifically, in 2008, the female population earned 16.5% less than men, worsening a little in 2020 to record a figure of 19.4% less than men. In Eastern European countries (Romania, Bulgaria, Slovenia, Hungary and Latvia), the gender pay gap in the ICT sector increased between 2008 and 2020. The other countries display a negative trend reflecting an improvement of women's position in the labour market.

On the other hand, we see particularly worrying pay gaps in Lithuania (30.7), Slovakia (31.1) and Czechia (34.5); these are the highest values in 2008 and therefore the most serious, although 12 years later these countries have managed to reduce the inequalities. According to a report by the European Parliament (2020) a smaller gender pay gap does not necessarily mean more gender equality; indeed, a smaller gap can be seen in countries or sectors with less female employment, as is the case in the technological field. Large inequalities may indicate that women are more concentrated in low-wage sectors or that a significant proportion of them work part-time. Aksoy et al., (2021) show that the adoption of robots pushes up incomes, but also increases

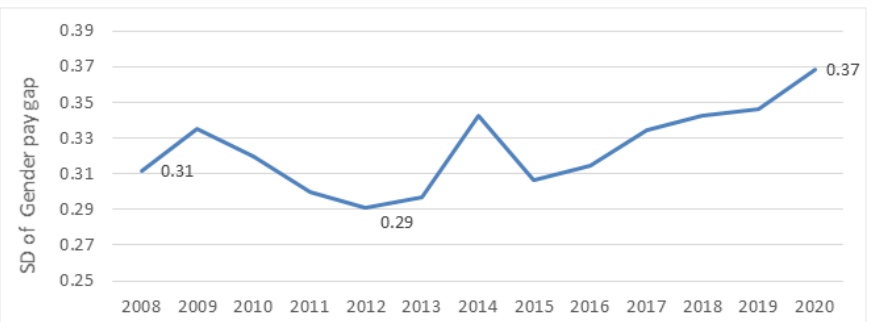
the gender wage gap, which may be the result of major economic powers such as Germany or Austria being above the European average.

Similarly to the employment indicators, we graphically analyse the beta convergence of the gender pay gap in the ICT sector to confirm whether there is an overall decline in the disparities among European countries in terms of wage differentials between men and women (Figure 9).



Source: Own elaboration.

Figure 9. β-convergence of Gender pay gap.



Source: Own elaboration.

Figure 10. σ-convergence of Gender pay gap (standard deviation).

Differences in the pay gap in EU countries have narrowed since 2008 for Cyprus (CY), Ireland (IE), Slovakia (SK) and Czechia (CZ), all places that initially registered high values, as shown in Figure 9 (lower right). However, the countries in the worst position in 2008 have registered much greater increases in their percentage (upper left), particularly Romania (RO) and Bulgaria (BG). Therefore, we can confirm the existence of beta convergence in the evolution of the wage gap. Again, the equation yields a negative estimated coefficient (-0.027) although the low R^2 value indicates the model fit is not particularly good.

On the other hand, sigma convergence represents the path followed by the Gender pay gap indicator, obtained from the standard deviation of this variable calculated annually for the 27 EU countries between 2008 and 2020 (Figure 10).

The dispersion of the ICT sector gender gap indicator does not show the same trend in all the years analysed. In Figure 10, we can distinguish a first period between 2008 and 2012 in which there is a decreasing trend, going from a standard deviation of 0.31 to 0.29, and a second period between 2012 and 2020 showing a continuing rise to a value of 0.37. All this demonstrates that disparities between countries have increased, but only very slightly. In this case it can be seen that even though beta convergence is confirmed, sigma convergence is not.

Conclusion

Research in the digital sector is crucial in order to remain at the forefront of technology. Equality between men and women is not only a fundamental right, but also an essential requirement for inclusive and sustainable growth. For this reason, boosting the female presence in the digital world is one of the measures to take to achieve a progressive society. In this vein, the present research has focused on the gender digital divide as it relates to Employed ICTS, Employed PICTE and Gender pay gap.

In the labour market, the female population is more concentrated in tertiary sectors such as education and health, while men hold more jobs in construction, the automotive industry or the technology sector. Eurostat data show these inequalities for the EU as a whole, but this research has focused on studying the direction countries have been taking in recent years to create a more egalitarian society.

Analyses of beta and sigma convergence of digital employment indicators confirm that European countries are reducing disparities, such that countries which initially had less of their population employed in ICT have grown faster than the more advanced countries in this regard, thereby achieving greater equality between them. In the case of gender pay gaps, beta convergence is confirmed, again indicating that EU nations are following a homogeneous trend in this variable. However, sigma convergence of the wage gap is not confirmed; disparities in the wage gap increase over the analysed period. All this indicates that the European institutions must improve their strategies to achieve greater wage equality and ensure all countries are moving in the same direction.

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References

Abbassi, F., & Haq, M. (2022). A spatial econometric analysis of convergence in global environmental performance. *Environmental Science Pollution Research*, 18139.

Aksoy, E. G., Özcan, B., & Philipp, J. (2021). Robots and the gender pay gap in Europe, *European Economic Review*, 134, 103693.

Aleksejeva, V., Lavrinenko, O., Betlej, A., & Danileviča, A. (2021). Analysis of disparities in the use of information and communication technology (ICT) in the EU countries. *Journal of Entrepreneurship and Sustainability*, 9(2):332-345.

Arroyo, L. (2020). Implications of Digital Inclusion: Digitalization in Terms of Time Use from a Gender Perspective. *Social Inclusion*, 8 (2), 180–189.

Azzoni, C. R. (2001). Economic growth and regional income inequality in Brazil. *The Annals of Regional Science*, 35, 133-152.

Barro, R. J. & Sala-i-Martin, X. (2004) *Economic growth*, 2nd edn. The MIT Press Cambridge, Massachusetts.

Biggeri, M., & Ferrone, L. (2022). Child Sustainable Human Development Index (CSHDI): Monitoring progress for the future generation. *Ecological Economics*, 192, 107266.

Boll, C., & Lagemann A. (2019). The Gender Pay Gap in EU Countries – New Evidence Based on EU-SES 2014 Data. *Intereconomics*, 54 (2), 101-105.

Crespo, J. & Uljas, S. (2021). Modelling and projecting digital trends in European regions: an econometric framework, *Regional Studies*, 55:10-11, 1696-1710.

De Andres, S., Collado, R., & Garcia-Lomas J. I. (2020). Brechas digitales de género. Una revisión del concepto [Digital gender gaps. A review of the concept]. *Revista científica electrónica de Educación y Comunicación en la Sociedad del Conocimiento*. 20 (1).

Duran, M. (2021). Digitalización y empleo: retos del futuro del trabajo desde una perspectiva de género [Digitization and employment: challenges of the future of work from a gender perspective]. *Revista de Estudios Jurídicos*. 21.

Eichhorst W., Hinte H., Rinne U., & Tobsch V. (2016). How Big is the Gig?. Assessing the Preliminary Evidence on the Effects of Digitalization on the Labor Market. *Management Revue*, 28 (3), 298–318.

EIGE. (2020). *Equality gender index 2020. Digitalisation and the future of work.* Luxembourg: Publications Office of the European Union.

Elena-Bucea, A., Cruz-Jesus, F., & Oliveira, T. (2021). Assessing the Role of Age, Education, Gender and Income on the Digital Divide: Evidence for the European Union. *Information Systems Frontiers,* 23(4), 1007–1021.

Eurostat (2018). *A decomposition of the unadjusted gender pay gap using Structure of Earnings Survey data*. Statistical Working Papers. European Union.

Gonzalez, M. I., Lopez, M., & Martinez, G. (2019). Desigualdad de género y convergencia en los paises de la UE-28 (2005-2015) [Gender inequality and convergence in the EU-28 countries (2005-2015)]. *Revista de Economia Mundial*, 53, 91-112.

Grześkowiak, A. (2020). Digital Skills, Gender and Earnings: Evidence from The Polish Labor Market. In K. S. Soliman, K. S. Soliman (Ed.), *Education Excellence and Innovation Management: A 2025 Vision to Sustain Economic Development during Global Challenges* (pp. 3278–3289). International Business Information Management Association (IBIMA).

Hari, A. (2016). Who Gets to 'Work Hard, Play Hard? Gendering the Work–Life Balance Rhetoric in Canadian Tech Companies,' *Gender, Work & Organization* 24, 2, 99–114.

International Labour Organization (2018). *Global Wage Report 2018/19: What lies behind gender pay gaps*.

ITU. (2019). *Measuring digital development*. Facts and figures 2019. Geneva: International Telecommunication Union.

Jaworska, R. (2014). Health inequalities across the European Union regions: A beta-convergence approach. *Comparative Economic Research. Central and Eastern Europe* 17(4), 71-86.

Karakaya, E., Yılmaz, B., & Alataş, S. (2019). How production-based and consumption-based emissions accounting systems change climate policy analysis: the case of CO_2 convergence. *Environmental Science Pollution Research* 26, 16682–16694.

Krchová, H., & Švejnová, H. K. (2021). Selected determinants of digital transformation and their influence on the number of women in the ICT sector. *Entrepreneurship and Sustainability*, 8(4), 524-535.

Krupowicz, J., & Kuropka, I. (2022) Convergence of Population Structures of the European Union Member States—The Past and the Future. *Sustainability* 14, 1024.

Larsson, A., & Viitaoja, Y. (2020). Identifying the digital gender divide. How digitalization may affect the future working conditions for women. In: A. Larsson & R. Teigland (Eds.), *The digital transformation of lab*or. *Automation, the gig economy and welfare.* New York: Routledge.

Lausi, G., Burrai, J., Barchielli, B., Quaglieri, A., Mari, E., Fraschetti, A., Paloni, F., Cordellieri, P., Ferlazzo, F., & Giannini, A. M. (2021). Gender pay gap perception: a five-country European study. *SN Social Science* 1, 267.

López M., Rohman I. K., De Prato G., Cardona M., Righi R., Samoili S., & Vázquez-Prada M. (2020). *ICT specialists in employment. Methodological no*te, Seville: European Commission, JRC119846.

López-Martínez, M., García-Luque, O. & Rodríguez-Pasquín, M. (2021). Digital Gender Divide and Convergence in the European Union Countries. *Economics*, 15, (1). 115-128.

Martin, A. M. (2020). La brecha digital generacional [The generational digital divide]. *Temas laborales*, 151: 77-93.

Martinez-Cantos, J. L., & Castaño, C (2017). La brecha digital de género y la escasez de mujeres en las profesiones TIC [The digital gender gap and the shortage of women in ICT professions]. *Panorama Social*, 25, 49-57.

Martinez-Cantos, J. L. (2013). Habilidades digitales y brecha de genero en Europa (2007-2011) [Digital skills and gender gap in Europe (2007-2011)]. *Revista de Estudios Empresariales*, 2, 4-28.

Martínez-Cantos, J. L., Castaño C., Escot, L., & Roquez, A. (2020). *Nuestras vidas digitales: barómetro de la e-igualdad de género en España* [*Our digital lives: barometer of gender e-equality in Spain*]. Otros. Ministerio de Igualdad: Instituto de la Mujer y para la Igualdad de Oportunidades., Madrid.

Miller, J. R., & Genc, I. (2005). Alternative regional specification and convergence of U.S. reginal growth rates. *The Annals of Regional Science* 39, 241-252.

Monnig A., Maier T., & Zika G. (2019). Economy 4.0-Digitalisation and Its Effect on Wage Inequality. *Jahrbucher Fur Nationalokonomie Und Statistik*, 239(3), 363–398.

Observatorio Nacional de Tecnología y Sociedad. (2021). Indicadores de género de la Sociedad Digital [Gender indicators of the Digital Society]. *Publicación Ministerio de Asuntos Económicos y Transformación Digital*.

OECD (2001). *Understanding the digital divide*, OCDE, Paris, 2001, https://www.oecd-ilibrary.org/science-and-technology/understanding-the-digital-divide_236405667766.

OECD. (2020). *A roadmap toward a common framework for measuring the digital economy*. Paris: OECD Publishing.

Parlamento Europeo (2020). *Brecha salarial de género en Europa: hechos y cifras* [*Gender pay gap in Europe: facts and figures*]. Available at. https://www.europarl.europa.eu/news/es/headlines/society/20200227STO73519/brecha-salarial-de-genero-en-europa-hechos-y-cifras-infografia

Perifanou, M. A., & Economides, A. A. (2020). Gender Digital Divide in Europe. International *Journal of Business, Humanities and Technology*, 10(4).

Petrakos, G., & Saratsis, Y. (2000). Regional inequalities in Greece. *Papers in Regional Science*, 79, 57-74.

Ragnedda, M., & Kreitem, H. (2018). The three levels of digital divide in East EU countries. World of Media. *Journal of Russian Media and Journalism Studies*, 1 (4), 5-26.

Sainz, M., Arroyo, C., & Castaño, C. (2020). Mujeres y digitalización. De las brechas a los algoritmos [Women and digitization. From gaps to algorithms]. *Publicaciones de la Administración General del Estado*. Instituto de la Mujer y para la Igualdad de Oportunidades. Ministerio de Igualdad.

Sala-i-Martin, X. (1996). Regional cohesion: evidence and theories of regional growth and convergence. *European Economic Review* 40, 1325-1352.

Sánchez – Vidal, M. E. (2016). La brecha salarial desde la perspectiva de la Dirección de Recursos Humanos, estudio de las causas y posibles soluciones [The wage gap from the perspective of the Human Resources Department, study of the causes and possible solutions] in Díaz, Capitolina y Simó - Noguera, C. [coords.], *Brecha salarial y brecha de cuidados, España: Tirant lo Blanch* [*Wage gap and care gap, Spain: Throwing the White*].

Segovia-Pérez, M., Castro, R. B., Santero, R., & Laguna, P. (2020). Being a woman in an ICT job: an analysis of the gender pay gap and discrimination in Spain. New Technology, *Work and Employment*. 35(1), 20-39.

Solarin, S. A. (2019). Convergence in CO_2 emissions, carbon footprint and ecological footprint: evidence from OECD countries. *Environmental Science and Pollution Research*, 26(3).

Solow, RM. (1956). A contribution to the theory of economic growth. *Quaterly Journal Economics*, 70(1), 65–94.

Suso, A. (2021). Brecha de género y digitalización: "dónde nos encontramos." [Gender gap and digitization: "where are we?"] *Revista tiempo de paz*, 141, 42-50.

van Kessel, R., Wong, B. L. H., Rubinic, I., & Czabanowska, K. (2021). Is Europe prepared to go digital? Making the case for developing digital capacity: an exploratory analysis of Eurostat survey data. *SocArXiv cfkxd, Center for Open Science*.

Vasilescu, M. D., Serban, A. C., Dimian, G. C., Aceleanu, M. I., & Picatoste, X. (2020). Digital divide, skills and perceptions on digitalisation in the European Union—Towards a smart labour market. *PLoS ONE* 15(4): e0232032.

Chapter 6

Women Tech Hub: Supporting Females to Accelerate the Digitalization of Their Start-Ups in Georgia

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Abstract

We are now living in a constantly changing context characterized by a high digital revolution that adds uncertainty and complexity to business managers and entrepreneurs around the world. Therefore, organizations are witnessing and leading many digital transformations that influence their strategies, policies and operations. COVID- has been a key driver for fast-tracking their digitalization journey. This study analyzes the role of digitalization in female owned businesses operating in Georgia, and the barriers they face during their startup process. We focus our findings on data gathered from female owned star-ups in Georgia, and student participants from both Georgia and the UK who are taking part in a collaborative project, the Women Tech Hub, to support the digitalization of those start-ups. We found that females were often driven by intrinsic motivation and faced barriers related to the lack of financial resources,

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knowledge and training, and mentoring and coaching. The findings show there is a need for a change in education and society to break with stereotypes and change mindsets to welcome and support females in the entrepreneurial landscape. Besides, we can say that both students and start-ups welcome these kinds of initiatives but Higher Education institutions need to take a much more active role in re-thinking their entrepreneurship education related pedagogies.

Keywords: digitalization, entrepreneurship, start-ups, females, Georgia

Introduction

Although today the concept of digitization occupies an important place among professionals and academics, digitization and digitization of business are not new topics of interest. In 1935 one of the earliest applications of computing power in business was the computerized registration of 26 million US citizens' employment records by IBM equipment to support the Social Security Act. Similarly, the first conference on artificial intelligence was held at Dartmouth in 1956. Hence, topics such as big data and artificial intelligence have been discussed for decades and have therefore been fields of interest for both professionals and academics (Ritter & Pedersen, 2020).

New phenomena appear and seem to be more and more applied in big and well-known firms, such as Alibaba, Accenture, Facebook, and Airbnb. In such companies, new implemented systems and technologies, like the Internet of Things (IOT), machinery automation and learning, artificial intelligence, drone phones, numerical technologies, Industry 4.0, connected clouds, robotization programs, or smart buildings, had proved to be effective tools for their development (Omrane, 2020).

Besides, as GEM report suggests in the majority of economies, new businesses are more likely to be started by men than women (Bosma et al., 2021). The fact is that gender stereotyping confines women to have qualities that are less likely to be associated with entrepreneurship (Hentschel et al., 2019) and this gender-based discrimination causes women to experience barriers for instance to acquiring financial capital in the form of loans (De Andrés et al., 2021).

So, how do female-owned start-ups adapt to this new reality in a resource-scarce environment? This chapter will present literature around digitalization, start-ups, and female entrepreneurship, to then talk about the Women Tech

hub, a collaborative project between UK and Georgia within the Creative Spark programme. We will look at how start-ups in Georgia are embracing their digitalization process and the barriers they are facing during that process, and how universities can support that process through collaborative projects.

Literature Review

Start-Ups and Digitalization

Entrepreneurs are called upon to develop various forms of venture companies based on diverse experiences, expertise, new technologies, as well as creative ideas. Such start-ups are expected to offer new flexible business models which are more appropriate to customers' expectations and generate high profits (Kim & Kim, 2018).

Chatterjeet et al. (2022) studied the contemporary demography of SME entrepreneurship and the moderating roles and potentialities of entrepreneurs' age, gender, and education in adopting digital platforms. They found that entrepreneurs who are already successful and who are efficiently using digital platforms will be role models to the start-up entrepreneurs. By understanding the success of other entrepreneurs who are using digital platforms, the start-up enterprises will be motivated to intend to use a digital platform. If the start-up entrepreneurs use the digital platform with their available resources, they are more willing to reach success.

If we consider the process of start-up and digitization in general, we will find many different definitions, but the most important thing in today's reality is that they are unimaginable without each other. Digitalization will be often seen as a way to change a business model and to provide new business opportunities but the definition of digitalization is still being discussed by academics, who are defining it as a social interaction too (Bloomberg, 2018).

In general, the word "start-up" means to start, but in the modern world this word has acquired a different meaning. The start-up is also not necessarily associated with technology activities or funding. Growth is the most important thing for a start-up, and everything else comes from this process (Graham, 2012). Kopp and Ganz (2016) in their book "Valley Speaks" say that a start-up is different from a small business in the way that while a small business may be content to remain small, a start-up intends to grow into a large company.

Current SMEs are already having to adapt to digitalization and within many areas of business being highly competitive, overlooking digitalizing their business risks losing new opportunities, loss of productivity and the loss of creating better ways of operating (Parviainen, Tihinen, Kääriäinen and Teppola, 2022). In the 21st Century, there is increasing accessibility to software and technology reducing risk for current and new entrepreneurs and decreasing the gap between larger organizations and new start-ups, allowing digitalization to be widespread (Trittin-Ulbrich, 2021). A study within Germany showed a shortage of IT skills or staff is the most commonly mentioned obstacle to digitalization within SMEs (Zimmermann, 2016), so although software and technology are becoming increasingly available, without access to people with the skills, start-ups will struggle to digitalize and miss out on the internal and external benefits associated.

When looking at digitalization related areas there is a wide range of options start-ups can take. For instance, website building and having a virtual space is now an important factor of being a successful start-up, but depending on the depth of resources an organization has it will impact their choice of the best way forward; factors like skills in-house, the scope of work, and economic resources affects how a website and other technology is used. A fully insourced website that is owned by the business and operated by an entrepreneur is shown to be the most cost-effective, further amplifying the need for entrepreneurs to have access to those technical skills to improve productive efficiency (Louw and Nieuwenhuizen, 2019).

When looking at ways startups and their employees go about implementing digitalization to start this journey, they typically prefer easy-to-implement technological tools that can adapt to quick changes regarding the business and its products/services (Giardino et al., 2014). With the lean methodology opted by many entrepreneurs and startups (Ries, 2011), having the appropriate easy-to-implement digital technologies and the skills needed to use these technologies in place to deal with any early changes a business goes through is important for the success of start-ups.

It is well-known that in the last few years the world has changed radically, and the development of technology and innovation has further accelerated the process of globalisation, where people from all over the world share emotions, culture, values, information, knowledge and more. This was followed by the development of information technologies, and the appearance of smartphones on the market, which made it possible to transfer various entrepreneurial and social activities to the virtual world.

This was one of the main reasons why standard businesses started digitising their product so that their product would always be available to consumers and they would not need to stand in long queues or travel long distances to buy the desired product or service. Customer needs and requirements are evolving and changing, as are business approaches. These processes have even led to the disappearance of some businesses.

IDC (2020) analyzed the situation of small businesses' digital transformation maturity after the COVID-19 crisis, across eight key nations around the world. The data showed that Covid-19 has had a significant role in the digitalization of start-ups and SME's with just under ¾ of the small businesses globally surveyed saying COVID-19 has been a key driver for fast-tracking their digitalization journey. During this period many businesses appeared that quickly adapted to the environment, and discovered needs and free spaces, which they tried to fill with their creative approaches and products. This was accompanied by the development of blockchain, crypto and NFT technologies, which provided additional leverage in the digital business in the form of smart contracts, enabling the storage of intellectual property in a unique digital format and their use for both commercial and collection purposes. Gamification (Gamify), EDufy, meta versions and various directions have been created to predict a fully digital world. Newly developed processes already in themselves push any start-up to digitise, as it makes the scaling process possible, which is one of the fundamental processes in a start-up.

The process of digitization has gradually become relevant for start-ups in Georgia as well. Thanks to digital technologies, start-ups have been allowed to scale, that is, to open up a larger area and opportunities to develop. Scaling is a structure that helps start-ups move to many countries and attract many people with one product and introduce new technology. The digitization process is making a big contribution to the introduction of this new technology, in which digital media also plays a very big role. Without digital media, these processes could not have developed.

Georgia has been actively involved in the process that the modern world has been following for a long time-establishment of a start-up ecosystem, and further its promotion and development. GITA - Georgian Innovation and Technology Agency operates based on the Ministry of Economy of Georgia to develop this direction. Through fablabs and regional technoparks, the agency tries to maximise the public interest in tech, creating new start-ups and their further development, which contributes to the process of digitization.

Since 2014, GITA has been trying to support start-ups, and give them resources and opportunities. It also often implements various awareness-raising projects aimed at better introducing and presenting the start-up firms ecosystem to the public. GITA actively offers start-ups funding programs in which it provides various categories of grants for local technology start-ups and ecosystem development. One of the particularly supportive projects that helps Georgian start-ups to develop and grow is the GITA grant project. For several years now, there have been 30,000, 100,000 and 150,000 GEL grant programs, the direct target group of which are tech start-ups. For example, in 2022, 20 technology start-ups received funding of 150,000 GEL, which is the biggest step in the development of the Georgian tech start-up ecosystem (Aridi et al., 2019). Also interesting in this process is the process that these start-ups go through before they get funding. Constant training, development and refinement of ideas are underway to further create and develop start-ups. The accompanying process is digitization. New start-ups are gradually being created - platforms, applications, and innovative ideas, which will further contribute to the development of the country.

In addition, there are various types of accelerators and incubators in the country that help start-ups develop and acquire resources. This helps in the process of digitization and scaling. Acceleration and start-up incubator programs often have departments of Ilia State University itself, Zoomout and Fablab.

With all this in mind, Georgian start-ups have gained great development since 2014. 500 start-ups were rolled in locally and shared some very important experiences as well. Based on the accumulated knowledge and experience, Georgian start-ups were able to present themselves even in the international arena. 500 Start-ups is one of the most active global venture capital companies in existence since 2010. To date, the company has invested in more than 2,400 companies in 77 countries. One of the top 3 accelerators in the world entered the Georgian market and thus actually expressed confidence in the ideas, talent and perspective of start-ups in the country (Bank of Georgia, 2022).

In summary, the development of structural start-ups and the process of their digitalization in Georgia is developing properly and the progress and success are growing accordingly.

Female Entrepreneurship

Much of the literature on entrepreneurship argues that socio-cultural factors such as fear of failure, perceived opportunities or role models are the most important drivers of entrepreneurial behaviour (Ajzen, 1991), especially in the case of female entrepreneurship (BarNir et al., 2011).

There is a lack of women in entrepreneurship, and this, therefore, affects social capital and access to resources. Female business networks are sparse and are found to either be too competitive or male-oriented (McGowan et al., 2015). Thus, there is a lack of sufficient and beneficial mentoring for females. This is compounded by the notion that a young woman cannot be successful both entrepreneurially and domestically simultaneously (Sandberg, 2013).

Aspiring females are likely to have lower levels of self-efficacy. They are often dismissive of entrepreneurship as a viable career choice and will choose a different career path if they believe they have a stronger skillset elsewhere (Wilson et al., 2007). This causes them to develop a risk aversion and are less likely to take risky entrepreneurial decisions. However, it has recently been suggested that the risk-taking propensity of women exceeds that of men, as by knowing the barriers they may face but still engaging with entrepreneurship, they exhibit a higher willingness to take risks than their male counterparts (Castillo et al., 2017).

As a result, there is a perceived irrelevancy of female entrepreneurship as an option within the educational system – perceiving entrepreneurial endeavours as inappropriate for young women, thus stopping the self-confidence necessary for the development of an entrepreneurial career. However, the further women progress through the system, the more likely they are to possess entrepreneurial skills (McGowan et al., 2015). Thus, there is a need for an education system that encourages the development of business skills from the outset of education, to encourage the development of aspiring females from all educational backgrounds (Jones, 2014).

Over the past 40 years, there has been a significant change in the status and political weight of women entrepreneurs, as well as a rapid increase in interest and research on the subject. The first articles were published in the 70s, expanding to various disciplines, methods and countries (Minniti and Naudé 2010). As a generalisation, start-ups created by women are smaller and grow less than businesses developed by men (Minniti, 2009).

The topic of female entrepreneurship has gradually become a growing area of interest and has attracted more attention towards them. This is mainly due to 2 main reasons: first, female entrepreneurship can be considered a key

source of economic growth, with different weights depending on the country and second, in different disciplines, female entrepreneurship has generally been an object of study (Ascher, 2012).

A growing number of women in recent years have decided to start entrepreneurial activities, which to some extent will have an impact on the entrepreneurial ecosystem and economic growth in the different world economies. According to a study from the World Bank, gender equality, which means that there are no differences between women's and men's earnings in the workplace, would be the cause of enriching the global economy by around $160tn (World Bank, 2018).

Georgia is no exception in this direction. Despite the high rate of women's involvement in business, politics and economics, the entrepreneurial sector remains a major challenge. In Georgia small businesses today face many challenges and these obstacles for business leaders grew even more complicated during the pandemic. One of the main challenges is gender equality. Unfortunately, gender equality is still one of the most discussed issues in Georgian families, in political as well as in business spaces. Female entrepreneurship is affected by existing stereotypes, which could be quite damaging as entrepreneurship is largely dependent on the environment, and society.

According to the National Statistics Office of Georgia, women entrepreneurs in the country have limited access to financial resources, which includes business and entrepreneurial loans, in comparison to men. The federation of business leaders "Women for Tomorrow "states that women have limited access to financial and information resources, which in turn poses great obstacles to their activities.

According to the Minister of Economy and Sustainable Development of Georgia, Natia Turnava, in 2015-2018, 9,380 people were funded under the Micro and Small Entrepreneurship Support Program, including 3783 women, which is 40% of the total number (Machitidze., 2020).

Encouraging female entrepreneurship is an important direction in the development of entrepreneurship, and in Georgia, different programs are doing this.

For example, YES-Georgia is a program initiated by the White House Foundation and USAID, which significantly helps Georgian women entrepreneurs in their economic empowerment. The program creates economic opportunities and empowers young people and women in Georgia. By 2024, more than 2,500 women entrepreneurs will have better access to knowledge, finance and business services (US Embassy Georgia, 2020).

USAID program in Georgia has been implemented since 2016. It should be noted special attention is paid to the regions of Georgia to involve as many women as possible from different locations.

Another exciting and supportive initiative for women entrepreneurs was the She's Next initiative, which was implemented in partnership with the Visa Business Leaders Federation Women for the Future and Forbes Woman Georgia. The She's Next initiative was launched in the United States in 2019 and aimed to empower women entrepreneurs by offering them educational activities. This initiative was global.

Also, as mentioned before, one of the main supporters for female start-ups is GITA through its Grant programs, as in 2022, 20 start-ups gained 150000 funding programs and part of them were female based start-ups (Georgian innovation and technology agency, 2022).

Due to these programs and support, the number of women entrepreneurs in Georgia and, consequently, their involvement in business has gradually become more significant in recent years. And since the onset of the pandemic, unfortunately, the number of enterprises and businesses has generally decreased, which has significantly hampered the strengthening of the economy.

Methodology

Methods and Participants

This research adopts a case study research strategy (Yin, 2009) and qualitative approach (Sunders et al., 2015) as it attempts to gain a deep understanding of the Why´s and How´s of a phenomenon in that particular context. Our study could be considered action research as "the authors are involved with members of an organization over a matter which is of genuine concern to them" (Eden and Huxham, 1996:75). Two of the co-authors are part of the organisations within which the research and the change process was taking place (Coghlan and Brannick, 2005).

We collected the data in May 2022. We sent surveys to start-ups run by females in Georgia (4 responses). Besides, we gathered the student participants' views through a survey. This included students in Georgia (15 responses) and the UK who acted as team coaches in the process (2 responses).

A thematic analysis was adopted as a framework to analyse the data. The main concepts that emerged were identified and categorized into common themes by different researchers. Statements and quotes allocated to the themes were then used to present a textural description of the qualitative and descriptive empirical data.

Table 1 shows the profile data of the start-up respondents. Specifically, the database of start-ups is made up of four women between 18-34 years old that started their businesses between 2018 and 2020.

Table 1. Profile of women-owned start-ups

Code	Age	Gender	Education	Employment status	Creation date	Entrepreneur type	Sector of activity
S1	25-34	Female	Postgraduate/ Master's	Employed	2019	Entrepreneur by creation	New technologies
S2	18-24	Female	Postgraduate/ Master's	self-employed part-time	2020	Entrepreneur by creation	Other
S4	25-34	Female	Secondary	Self-employed full-time.	2018	Entrepreneur by inheritance	Manufacturing
S5	25-34	Female	Bachelors' degree	Employed by someone else that acquired our company	2019	Entrepreneur by creation	New technologies

Source: Own elaboration.

In terms of the highest level of education, 50% have a Postgraduate/ Master's degree, followed by 25% with Secondary and Bachelors' degree. In regards to the statement that best describes their current employment status employed (50%) and self-employed 50%). Most of them (75%) started a business project from scratch and the 25% I continued a family business.

Regarding their Management experience, there are 75% of the respondents have experience of between 1 and 5 years and the remaining 25% between 6 and 10 years.

The profile of the Georgian student participants is made up of fifteen women from different university degrees in Ilia State University, most of them between 18-24 years old. The highest level of education that they have completed has been *bachelors' degree* (53,33%), next *secondary* (33,33%), followed by *postgraduate/ master's degree* and *vocational* with the same percentage (6,67%). Many of them are employed (46,67%), followed by *self-*

employed (26,67%), and then *unemployed* (20%). Only a few were *self-employed and employed by someone else* both (6,67%).

Table 2. Profile of 15 student participants from ISU, Georgia

Code	Age	Gender	Education	Employment status	Direction tech hub
P1	18-24	Female	Bachelors' degree	Unemployed	Web-development
P2	18-24	Female	Secondary	Self-employed	Web-development
P3	18-24	Female	Bachelors' degree	Self-employed	Graphic Design
P4	18-24	Non-binary/ third gender	Secondary	Employed	Web-development
P5	18-24	Female	Vocational	Employed	Graphic Design
P6	18-24	Female	Bachelors' degree	Unemployed	Web-development
P7	18-24	Female	Secondary	Unemployed	Graphic Design
P8	25-34	Female	Bachelors' degree	Employed	Graphic Design
P9	18-24	Female	Bachelors' degree	Employed	App-Development
P10	18-24	Female	Postgraduate/ Master's	Self-employed and employed	Graphic Design
P11	18-24	Female	Bachelors' degree	Employed	Graphic Design
P12	18-24	Female	Bachelors' degree	Employed	App-Development
P13	18-24	Female	Secondary	Employed	Graphic Design
P14	18-24	Female	Secondary	Self-employed	Social media
P15	18-24	Female	Bachelors' degree	Self-employed	Web-development

Source: Own elaboration.

In terms of the area of specialization, they took within the Women Tech Hub most of them are working on *Graphic Design* (46,67%), then *Web-development* (33,33%), followed by *App-Development* (13,33%) and *Social media* (6,67%).

Table 3. Profile of 4 participants from UWE, UK

Code	Institution	Level	Programme	Gender	Role in Women Tech
R1	UWE, UK	Year 3	Team Entrepreneurship	Male	Team Coach Team 1
R2	UWE, UK	Year 3	Team Entrepreneurship	Male	Team Coach Team 4
R3	UWE, UK	Year 3	Team Entrepreneurship	Female	Team Coach Team 3
R4	UWE, UK	Year 3	Team Entrepreneurship	Female	Team Coach Team 2

Source: Own elaboration.

All of these students from the University of the West of England (UK) that acted as team coaches were final year students that had previous experience as assistant team coaches within the programme and in other international projects. 50% of them were undertaking coaching training too. 50% were females and 50% males.

The Research Setting

Georgia is located at the crossroads between Asian and European cultures in the South Caucasus region. Georgia holds a unique geographic, cultural and political significance. Long-standing unresolved political conflict with Russia over the occupied regions of Abkhazia and South Ossetia, a lack of inclusive and diverse economic models, and poor social inclusiveness/ minority integration are all major contributing factors that hold the region susceptible to instability. In 2019, the UK and Georgia signed a Strategic Partnership and Cooperation Agreement. Developing resilience for citizens is a determining factor in creating a society in which people can thrive, with international expertise being crucial to achieving this. In Georgia 33 government-authorised higher education institutions are offering three cycles of education, and 20 higher education institutions offer two cycles of education. Georgian education and culture system operates within Culture Strategy 2025 and United Strategy of Education and Science 2017-21. These policies and initiatives facilitate entrepreneurship within creative industries and vocational education. However, it is still not embedded as a priority within the government's overarching strategies (British Council, 2021).

The Partnership

The Women Tech Hub project is a collaborative project between the University of the West of England (Bristol, UK) and Ilia State University (Tbilisi, Georgia) as part of the Creative Spark Higher Education Enterprise Programme, a five-year initiative (2018 - 2023) funded by the British Council to support Higher Education and institutional partnerships with the UK to develop entrepreneurship and enterprise skills for students and young entrepreneurs.

As it is known, the Creative Spark Higher Education Enterprise Programme supports partnerships to develop enterprise skills and creative economy across seven countries in Central Asia (Kazakhstan, Uzbekistan, Kyrgyzstan), South Caucasus (Azerbaijan, Armenia, Georgia) and Ukraine through UK support. These partnerships aim to support the following areas: Skills development for students and young creative entrepreneurs; Supporting new business activation and incubation; Knowledge exchange. The programme has been developed in response to an underdeveloped creative

sector and a demand for entrepreneurship training in the programme countries, supporting wealth and job creation.

Within the programme Ilia State University collaborates with the University of The West of England in Bristol (UWE Bristol), and is sharing experience, working on delivering entrepreneurial education to the young generation.

The University of the West of England, Bristol (UWE Bristol) is a public research university, located in and around Bristol, England, which received university status in 1992. UWE can trace its origins to the Merchant Venturers' Technical College, founded as a school in 1595 by the Society of Merchant Venturers (UWE, 2022). UWE's strategy 2030 continues to look at Enterprise to "power the local economy" and as one of the universities' values. UWE wants "an enterprising culture throughout". Tiimiakatemia was developed in 1993 by Johannes Partanen at Jyväskylä University of Applied Sciences (JAMK) in Finland. Within Entrepreneurship Education, Team Academy (TA) is seen by some as an innovative pedagogical model that enhances social connectivity, as well as experiential (Kayes, 2002; Kolb, 1984), student-centred (Brandes and Ginnis, 1986) and team-based learning (Michaelsen et al., 2004). It also creates spaces for transformative learning to occur (Mezirow, 2006). "If you want to see the future of management education, you should see Team Academy" Peter Senge (2008) made this comment over a decade ago about TA and since its inception, educators and practitioners engaging in TA based programmes have continuously pushed at the innovation boundaries of more traditional teaching approaches to education (Urzelai and Vettraino, 2022a, 2022b; Vettraino and Urzelai 2022a, 2022b). TA is often referred to as a model of entrepreneurship education (Sear and Norton, 2012) and the way it takes the learning through approach (Hytti and O'Gorman, 2004; QAA, 2018). UWE Team Academy (Team Entrepreneurship programme) is seen as the flagship programme for the University of the West of England (UWE) in terms of being enterprising and UWE TA has been recognized as a first and leading example of the TA methodology in the UK, achieving, beyond others, the Collaborative Award for Teaching Excellence from Advance HE in 2021.

Ilia State University (ISU) was established in 2006 and currently has 17000 students. ISU has successfully managed several international projects related to development of new curriculums, STEM popularisation, the introducing modern technologies in teaching, tech entrepreneurship, etc. During the last decade, ISU has implemented many activities in this direction by organising a yearly Science Picnic, working with the Young Scholars

Network to help public school teachers in developing school STEM clubs, providing training in ISU Physics and Biochemistry labs and helping to establish such labs in regional schools, offering STEM Academies, having Fablab and Unilab offering extracurricular training, establishing Google Developer Club and organising Tech Hackathons. Other collaborations include work with GITA, Geolab, Innovative Education Foundation, UNDP, and UN Women Georgia.

The achieved results from previous years with Ilia State University (Tbilisi, Georgia), UWE and Creative spark are meaningful in terms of knowledge and trained human resources who are ready to take a lead skewed towards the local side to implement the sustainability measures. The focus of this year's commitment will be on sustaining the engagement of female participants and building female tech education and training to get more women in tech and entrepreneurship. This complements well with previous attempts to build enterprise education and resources and is completely a new addition to our ecosystem and programmes in this area. Recently ISU has created Tech Entrepreneurship and Innovation Development Centre where it runs several programmes, organises events and provides services to students and staff. In the 4th-year Creative Spark project, Women Tech Hub aims to support female students who wish to master new professions and develop their skills in technological and entrepreneurial directions.

As ISU and UWE continue to see community transmission of COVID-19 and the need to minimise its spread, a balance must be struck in how educational opportunities are offered. During the COVID-19 outbreak, when all the public and private institutions were forced to close, UWE and ISU managed to implement the forthcoming activities by fully transforming the face-to-face formal educational approach to online attendance.

During these years Ilia State University (Tbilisi, Georgia), UWE (Bristol, UK) and Creative spark: trained human resources who are ready to take a lead skewed towards the local side to implement the sustainability measures; delivered enterprise skills training packages to students and creative entrepreneurs, ranging from pitching ideas and starting a business, to protecting intellectual property and securing financial support; Delivered an English Learning Programme with a range of new digital language learning content. This included online learning packs on the English Channel platform, online courses and new Massive Open Online Courses (MOOC) focused on English for entrepreneurship.

Women Tech Hub Project

The objective of this year's project (Women Tech Hub) is to train female students in digitalization related topics (tech entrepreneurship, app development, computer design and social marketing) to then facilitate the matching of the trained students who will help start-ups founded by women, mostly by female ex-inmate and conditionally convicted to accelerate, develop and design their website, and apps if needed. During the process, the students get not only training but coaching and mentoring support. The program aims to accelerate and develop digital platforms for those start-ups.

On February 7th, 2022, a call was announced to receive applications for joining the Project-Women Tech Hub. The deadline was given till February 25th. The call was announced on Facebook pages of Ilia State University and Fablab Ilia university, also on Ilia State university's webpage. Information about the project was delivered to the students via E-mails and through other communication channels. In total 180 applications were received, from students of different professions, who want to develop skills in various modern areas, such as: tech entrepreneurship; web development; app development; social marketing; computer design.

At the end of the training period, a group of relevant participants will help the start-ups founded by women, mostly by female ex-inmate and conditionally convicted to accelerate, develop and design websites and apps. At least 6 start-ups will be helped.

Findings

This section shows the main results of the surveys obtained regarding motivations to start a business, barriers that start-ups face and how the Women Tech Hub programme provided a solution for this.

Motivations for Starting a Business

Below the responses that women-owned start-ups gave around their reasons and motivations to start their ventures.

Table 4. Motivations of start-ups to start a business (average values)

	Average
To have greater FLEXIBILITY for my personal and family life	4.3
To have considerable FREEDOM to adapt my own approach to work	4.8
To earn a larger personal INCOME	4.3
To have a chance to build great WEALTH or a very high income	4.3
To fulfil a personal VISION	4.8
To CHALLENGE myself	5.0
To continue a family TRADITION	3.3
To follow the example of a person I ADMIRE	2.5

Source: own elaboration.

We can see that the reasons for starting a business with higher response are: to challenge myself, to fulfil a personal vision, to challenge myself and to have considerable freedom to adapt my own approach to work.

It is interesting that these reasons, as compared to those for males, are mainly linked to intrinsic motivations and internal rewards, rather than external motivations such as economic and income related rewards. These results are confirmed in other studies carried over with entrepreneurship students in the UK (Urzelai, et al., in press).

Barriers to Women Start-Ups and Their Digitalization Process

Table 5 shows the barriers and limitations women-owned start-ups faced when setting up and running their ventures.

The main barriers for starting a business are: other (resistances and industry knowledge), limited access to financial support, low level of legal and economic knowledge, and lack of mentoring and coaching.

It looks like even if there are increasing initiatives to provide funding for start-ups in Georgia the females entrepreneurs still see this as a main limitation. Training and coaching are clearly needs that start-up firms have. The Women-Tech Hub programme aims to cover these needs by training students to then transfer that knowledge to the start-ups and support them in their digitalization. Besides, these students are given coaching support that they can them use in working with those start-ups.

Table 5. Barriers and limitations faced by start-ups (average values)

	Average
Gender stereotyping and role of women in society	3.6
Limited access to financial support	5.0
Limited access to human resources	3.4
Limited Access to Training and Equipment	3.4
Lack of self-confidence	2.8
Differences in educational level	2.0
Discrimination and sexual harassment	4.0
Lack of mentoring and coaching	4.4
Lack of role models	3.2
Lack of networks	3.6
Lack of work-life balance	4.0
Lack of ambition for success	3.4
Personal attitude towards risk-taking	3.2
Not been taken seriously or been patronised	4.2
Low level of legal and economic knowledge	4.6
Lack of supportive digital technologies	2.6
Lack of self-efficacy (belief in your capacity to execute)	3.8
Family barriers (family members' disapproval...)	3.6
Cultural barriers (societal norms and traditions)	3.0
Fear of failure	3.0
Male domination in the industry/ sector	3.4
Other	5.6

Source: Own elaboration.

The Georgian student participants believed that the main barriers women-owned start-ups face when running a business are (ordered from highest to lowest frequency of response):

- Limited access to financial support (73,33%)
- Gender stereotyping (66,66%)
- Lack of self-confidence (60%)
- Family barriers (46,66%)
- Limited Access to Training (33,33%)
- Discrimination/ sexual harassment (26,66%)
- Limited access to human resources (26,66%)
- Lack of ambition for success (26,66%)
- Differences in educational level (20%)
- Lack of networks (13,33%)

The qualitative data from these students indicated that, apart from the financial difficulties, students that were self-employed thought that the main barriers were those related to more personal, psychological and societal barriers, such as fear of failing, lack of ambition or attitudes and stereotypes:

> "I think, attitudes. Some people think that technologies aren't for women, because they need practical, technical knowledge/skills" (P10).
>
> "I think the main barrier is trust and financial problems, mentality towards women in our country is making them quit too fast, or making them not start at all" (P3)
>
> "I think lack of trust due to stereotypes hinders finding a team" (P2)
>
> "It is hard for me to say exact answer but my point of view that's education, there are few females in IT faculty, but day after day this trend changes and that's very pleasant. Also, there can be other factors such as the fear of failure, many females think too much and are scared to take another step, while males take it too fast and risk everything that they have, sometimes it's necessary to risk to win. Also, the main point can be money-sponsors, who will rely on this idea (P14)
>
> "Family barriers, lack of ambition for success" (P15).
>
> "The stereotypes as people think females are bad in tech and that digitalization is not the field they know" (P4).

There is a need for a change in education and society to break with stereotypes and change mindsets to welcome and support females in the entrepreneurial landscape.

The Women Tech Programme as a Collaborative Solution

In general, the expectations that student participants in Georgia had when joining the programme were, to have new knowledge, new experience, new chances, new perspectives (46,67%), find a suitable job after the course (46,67%) and don't have precise expectations yet (6,67%).

The main reason why they decided to join the Women Tech Hub it was mainly to have experience and knowledge in the business and tech field (35,72%), to improve their skills (14,29%), to learn about graphic design and start working in that field (21,43%) and to show interest in technologies. Besides, to have a good start app idea, to study programming and get practice in this field, to study web-development and to try something in a different field (7,14%).

When looking closer at the reasons why they joined and the expectations they had, we identify three main areas:

1) Increasing their knowledge and learning in that discipline/ topic of technology:
   "To gain more knowledge in this area and also to get more experience" (P6)
   "To learn about the graphic design and start working in that field" (P7)
   "I'm interested in technologies, besides this, I have a good start app idea" (P10)
2) Students interested in just trying new things or improving other skills:
   "I wanted a new experience {…} better ability to contact business I'd like work with and better potential for them to see in me"(P3).
   "I wanted to improve my skills" (P5)
   "to improve myself" (P9)
3) Students see this as an opportunity for their future both in education or the workplace:
   "My motivation is to gain some experience and knowledge in the business and tech field and I thought that it would be a great opportunity for my future plans. I hope that I will be able to get some practical skills during supporting the start-ups that will help me, in the future, become an experienced and competitive employee" (P1).
   "This project is an excellent opportunity for me to move forward and take the next steps in this profession, which I would like to use I hope I will have an opportunity for an internship" (P2).
   "I have a desire to study programming and get practice in this field" (P12)
   "I want study Web-development" (P15)
4) The desire to help other start-ups or start their own business:
   "To get enough knowledge to help start-ups and also find a job in this field" (P4)
   "I hope that I will be able to get some practical skills during supporting the start-up" (P11)
   "This program will give me the determination to start another one, get experience and never stop" (P14).

When asked about this last element on how they thought they will help start-ups after the completion of the programme the participants mentioned they want to do the best with the knowledge acquired (66,67%), and they want to support start-ups by creating functional websites for their business

(26,67%). Others don't know yet how they will be able to support them (6,67%).

Besides, students seemed to have already identified areas they want to work with, organizations they want to work with or other elements of the start-ups that attract them:

> "I am going to support start-ups by creating a website for their business" (P1, P4)
>
> "I think I can help start-ups with my program skills, I can make logo, poster for ad, etc." (P8).
>
> "I plan to create some app or web page for start-ups and help them to grow" (P12)
>
> "Someone at Women Tech Hub has already offered me to help with her start-up, which I agreed to" (P2)
>
> "I really love start-up culture, I think you grow the most with them, you're out of your comfort zone and trying your best. Right now, I'm working with Georgian start-ups and I'm hoping to have more and more interaction with people who try their best to succeed and make life better for all of us" (P3)
>
> "At the beginning of the course I had no knowledge of start-ups and no ideas but at the end of the course I will start thinking about my idea and then I will try to implement it slowly" (P6).
>
> "Helped me to understand the basics of marketing, how social networks actually work, all this information together will help me to start something new independently or help new start-ups" (P.14).
>
> "It'll be a start for my career in this field" (P7).

In terms of what Georgian students intend to do to after the programme, they seem to have future plans regarding acquiring further skills around graphic design in order to provide their technical support (40%), to continue helping start-ups see advantages of digitalization and help them become digital (53,33%). Some still don't know well how they will go with it after the programme (6,67%).

The learnings acquired from the programme show the students were developing their self-awareness and reflective skills and thinking about not only the knowledge they were gaining, but also the connections they were making and the future they want to take:

> "It helped me to find out more about how to pursue my profession after listening to the advice of people who are already experienced" (P2)

> "I think I better understand start-up culture now, I understand what they need from me, what I can give them and on what I can work to be a better fit for any company I want" (P3).
>
> "I have found more about my abilities and what could I do" (P11).
>
> "I will be experienced and more confident in my field" (P5).
>
> "The main thing I gain from training/trainers is that they show us possibilities, give us motivation and channels, we can use to execute our ideas" (P10).

The students reflected on how the knowledge gained in the programme will help them in the future, and they recognized that they could expand their knowledge about graphic design and that it'll be a start for their career in that field (33,33%). They were also able to understand better start-up culture.

The UK-based students who acted as the participants' team coaches throughout the project identified a pedagogical gap in the participants' home institution in terms of having a more self-managed and student-led programme that builds on their confidence and experiential learning.

> "My experience of coaching a team of women training within the field of digitalization related topics (tech entrepreneurship, app development, computer design and social marketing), I saw a lack of confidence, and a reluctance to test their skills with a fear of failure being a huge factor. A way a university can support these individuals is to provide a safe space to test their skills and apply their current knowledge to projects. By doing so within teams with a team coach to support the process it should increase the risk taking of the individuals and reduce the fear of failure. Another alternative is to provide opportunities with limited risk and consequences for students to explore and engage with, applying their knowledge and learning by doing" (R1).

It seems that students are very passionate about what they are doing and have entrepreneurial intentions, but coaching and mentoring could be needed within the educational system:

> "In terms of how Universities can help with the digitalisation of businesses and empowering females to do so, I think a massive help is education. With Universities in Georgia offering their students a chance to learn these skills, I have noticed a real passion to succeed from my students, and a willingness to build their websites or apps by themselves, with little external guidance. The difficult thing with entrepreneurship is the feeling of not knowing how or when to start, but with this education, it can really give them the tools and

> confidence to just give it a go. I noticed three main challenges: capacity to build a team, confidence to out and find the right people, and portraying their idea simply and clearly for others to understand and get behind it (R3.

They also detected reluctancy to test their skills and a need to ensure gender isn't seen as a problem in Georgia.

> "What I observed coaching them is that there is a need to ensure gender isn't seen as a problem. This could be done by using female success stories in parallel to male success stories, promoting discussions around Georgian economic success, etc. I noticed cultural beliefs influenced their thinking around whether females could be successful leaders, CEO's, founders, etc. Potentially more needs to be done to generalize awareness of these individuals. The programme provided them with the opportunity to learn and practice. The students were naturally very academic but lacked exposure to practice (as this did not come naturally to them) so more opportunities to do so is definitely needed" (R2).

Conclusion

There is no doubt that digitization and digitalization of business are very popular topics in today's world, and that it is helping start-ups, as well as businesses in development. In the process of globalisation, with the rapid development of information technologies, it has become possible to implement global start-up activities in the virtual space. It can be said that in the development of technology start-ups, digitalization has played a special role. The spread of the Internet, the increase of information, and the introduction of various technological innovations, helped the start-up ecosystem to develop rapidly. Despite the challenges caused by COVID-19 and the pandemic, the majority of start-ups were able to develop and innovate, and create new products which were adapted to the market's main needs. With this process, digitalisation was the key. This is true especially in regards to the Georgian ecosystem.

As for female entrepreneurs, it is true that nowadays their number is gradually increasing and more women are trying to start their ventures. However, there are still obstacles that are related to various factors. Some of the main reasons preventing them to grow and develop are the limited access to financial support, the lack of mentoring and their limited legal and economic knowledge. Discrimination and family problems are also important issues.

This causes obstacles not only in Georgia, but also in different countries, which needs special attention to find solutions.

Role models are important when it comes to female entrepreneurship, and even more when we talk about tech entrepreneurship, as many stereotypes impose barriers and limitations on females in this sector. These individuals need to build their self-confidence to become more ambitious and determined to follow their entrepreneurial dreams. The fact is that female owned start-ups are often driven by intrinsic motivations, such as the need the have to fulfil their personal visions or to be challenged. These are important factors that help them build their entrepreneurial mindset, which is one of the main important things that drive a person to succeed.

Also, a very important part of promoting start-ups is acknowledging that young generations need personal growth and development in the workplace and are willing to learn new things and develop lop their our futures. Students from the "Women Tech Hub project" are studying different degrees but they are all motivated in helping start-ups to digitalize their products. With the acquired knowledge (web development, app development, graphic design and social media), that has been recognized to be missing in the system, they are going to support women start-ups in different digitalization directions. For newly developed start-ups this would be a huge help, as they are in an early stage of development. So, programs like these would benefit a lot more female owned start-ups and encourage them to continue working on what they believe, and help students acquire transversal skills and cross-cultural competencies for their future careers.

One of the main reasons why they joined the program was to get practical experience, something that we found was not embedded enough in their programs. The Higher Education sector needs to focus much more on providing enterprise and entrepreneurship training that is fully integrated into all types of university degrees. The Women Hub Tech is an example of extra-curricular activities students can take to develop these skills, but it is not enough to offer these if they cannot continue being fully engaged in practice. Experiential and practice-led learning pedagogies need to shape the current programme designs and assessments. Georgia already has various initiatives and programmes to encourage female entrepreneurship, but unless these students develop a higher level of self-awareness and build their confidence, they will not fully engage as active agents in that dynamic entrepreneurial ecosystem.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50, 179–211.

Andrés, P., Gimeno, R. & Mateos de Cabo, R. (2021). The gender gap in bank credit access. *Journal of Corporate Finance*, *71*, p.101782.

Aridi, A., Kapil, N., Ytreland, A., Hayter, C. S., & Li, Y. (2019). *Innovation agencies: Cases from developing economies.* Washington, D.C.: World Bank Group. https://documents1.worldbank.org/curated/en/615921573678530574/pdf/Innovation-Agencies-Cases-from-Developing-Economies.pdf (Accessed May 2022).

Bank of Georgia (2022). *About 500 Startups.* Available from https://bankofgeorgia.ge/en/business/startups. (Accessed 17 June 2022).

BarNir, A., Watson, W.E., & Hutchins, H. M. (2011). Mediation and moderated mediation in the relationship among role models, self-efficacy, entrepreneurial career intention, and gender. *Journal of Applied Social Psychology*, 41(2), p. 270–297.

Bloomberg, J. (2018). Digitization, digitalization, and digital transformation: confuse them at your peril. *Forbes.* Retrieved on August, 28, 2019.

Bosma, N., Hills, S., Ionescu-Somers, A., Kelley, D., Guerrero, M., & Schott, T. (2021). *Global Entrepreneurship Monitor (GEM) 2020-21 global report*. Babson Park, MA: Babson College. Available at: (Accessed January 2022). https://www.gemconsortium.org/file/open?fileId=50691 (Accessed January 2022).

Brandes, D., & Ginnis, P. (1986). *A guide to student centred learning*. Oxford: Blackwell.

British Council (2021). *Request for proposal (RFP) for Creative Spark in Georgia*. Date: 31 May 2022. Revised January 2021.

Castillo, M., Dickinson, D.L. & Petrie, R. (2017). Sleepiness, choice consistency, and risk preferences. *Theory and Decision*, *82* (1), p.41-73.

Chatterjee, S., Chaudhuri, R., Vrontis, D., & Thrassou, A. (2022). SME entrepreneurship and digitalization–the potentialities and moderating role of demographic factors. *Technological Forecasting and Social Change*, *179*, 121648.De.

Georgian innovation and technology agency (2022). *The winners of the 150,000 GEL co-financing grant program.* Available from https://bit.ly/3NhP38M (Accessed 17 June 2022).

Giardino, C., Unterkalmsteiner, M., Paternoster, N., Gorschek, T. & Abrahamsson, P. (2014). *What Do We Know about Software Development in Startups?*. *IEEE Software*, 31(5), pp.28-32.

Graham, P. (2012) *Startup = growth*. Available at: http://www.paulgraham.com/growth.html http://www.paulgraham.com/growth. (Accessed 17 June 2022).

Hentschel, T., Heilman, M.E. & Peus, C.V. (2019). The multiple dimensions of gender stereotypes: A current look at men's and women's characterizations of others and themselves. *Frontiers in psychology*, *10*, p.11.

Hytti, U. & O'Gorman, C. (2004). What is 'enterprise education? An analysis of the objectives and methods of enterprise education programmes in four European countries', *Education and Training*, 46 (1): 11-23.

IDC (2020). *Small Business Digital Transformation; A Snapshot of Eight of the World's Leading Markets*. Available from https://www.cisco.com/c/dam/en_us/solutions/

small-business/resource-center/small-business-digital-transformation.pdf (Accessed 15 June 2022).

Jones, S. (2014). Gendered discourses of entrepreneurship in UK higher education: The fictive entrepreneur and the fictive student. *International Small Business Journal*, *32* (3), p.237-258.

Kayes, D. C. (2002). Experiential learning and its critics: Preserving the role of experience in management learning and education. *Academy of Management Learning & Education*, *1* (2), 137–149.

Kim, B., Kim, H., & Jeon, Y. (2018). Critical success factors of a design startup business. *Sustainability*, *10*(9), 2981.

Kolb, D. A. (1984). *Experiential learning: experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

Kopp, Rochelle & Ganz, Steven (2016). *Valley speak: Deciphering the jargon of Silicon Valley*. Genetius Publishing.

Louw, C. and Nieuwenhuizen, C. (2019). Digitalization strategies for SMEs: A cost vs. skill approach for website development. *African Journal of Science, Technology, Innovation and Development*, 12(2), pp.195-202.

Machitidze, M. (2020). *Female Entrepreneurs and USAID Support*. Forbes woman Georgia Available from https://www.forbeswoman.ge/post/usaidwomen. (Accessed17 June 2022).

McGowan, P., Cooper, S., Durkin, M. & O'kane, C (2015). The influence of social and human capital in developing young women as entrepreneurial business leaders. *Journal of Small Business Management*, *53* (3), p.645-661

McGowan, P., Cooper, S., Durkin, M. & O'kane, C. (2015). The influence of social and human capital in developing young women as entrepreneurial business leaders. *Journal of Small Business Management*, *53* (3), p.645-661.

Mezirow, J. (2006). An overview of transformative learning. In P. Sutherland & J. Crowther (Eds.), *Lifelong learning: Concepts and contexts* (pp. 24-38). New York: Routledge.

Michaelsen, L. K., Knight, A. B., and Fink, L. D. (2004). *Team-Based Learning: A Transformative Use of Small Groups in College Teaching.* Sterling, Va.: Stylus.

Omrane, A. (2020). Which Are the Appropriate Skills Needed for the Entrepreneurial Success of Startups in the Era of Digitalization?. In *Developing Entrepreneurial Competencies for Start-Ups and Small Business* (pp. 215-235). IGI Global.

Parviainen, P., Tihinen, M., Kääriäinen, J. and Teppola, S. (2022). Tackling the digitalization challenge: how to benefit from digitalization in practice. *International Journal of Information Systems and Project Management*, 5(1), pp.63-77.

QAA (2018). *Enterprise and entrepreneurship education: guidance for UK higher education providers.* Gloucester. QAA (The Quality Assurance Agency for Higher Education). Available from www.qaa.ac.uk/docs/qaas/enhancement-and-development/enterprise-and-entrpreneurship-education-2018.pdf?sfvrsn=15f1f981_8. (Accessed 3rd January 2019).

Ries, E. (2011). *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses*. Currency.

Ritter, T., & Pedersen, C. L. (2020). Digitization capability and the digitalization of business models in business-to-business firms: Past, present, and future. *Industrial Marketing Management, 86*, 180-190.

Sandberg, S. (2013). *Lean in: women, work, and the will to lead*. Random House. New York.

Sear, L. & Norton, S. (2012). *Essential frameworks for enhancing student success: Enterprise and Entrepreneurship A guide to the Advance HE Framework for Enterprise and Entrepreneurship Education.* Advance HE. Available at: https://www.advance-he.ac.uk/knowledge-hub/tags/leigh-sear (Accessed 15th June 2017).

Senge, P. (2008). *Peter Senge -Team Academy*. Tiimiakatemia Global Ltd., Youtube channel. https://www.youtube.com/watch?v=kWENQJHp-U8

Trittin-Ulbrich, H., Scherer, A. G., Munro, I., & Whelan, G. (2021). Exploring the dark and unexpected sides of digitalization: Toward a critical agenda, *Organization*, 28(1), pp. 8–25.

Urzelai, B. & Vettraino, E. (2022). *Team Academy in practice*. Routledge Focus on Team Academy. Abingdon: Routledge.

Urzelai, B. & Vettraino, E. (2022). *Team Academy in Diverse Settings.* Routledge Focus on Team Academy. Abingdon: Routledge.

Urzelai, B., Davies, L., & Watkins, S. (in press). Female entrepreneurs' motivations, intentions and barriers in Higher Education: A case study from Team Academy Bristol. In *FGF* volume on Progress in Entrepreneurship Education and Training: New Methods, Tools and Lessons Learned from Practice, Springer. Springer.

Urzelai, B., Davies, L., & Watkins, S. (in press). Female entrepreneurs' motivations, intentions and barriers in Higher Education: A case study from Team Academy Bristol. In *FGF* volume on Progress in Entrepreneurship Education and Training: New Methods, Tools and Lessons Learned from Practice, Springer. Springer.

US Embassy Georgia (2020). *YES-Georgia launches to support youth and women entrepreneurship (January 31).* Available from https://ge.usembassy.gov/yes-georgia-launches-to-support-youth-and-women-entrepreneurship-january-31/ (Accessed 17 June 2022).

UWE (2022). *UWE history timeline – UWE Bristol: History.* Available from: https://www.uwe.ac.uk/about/our-history. (Accessed 15th June 2022).

Vettraino E. & Urzelai, B. (2022). *Team Academy and Entrepreneurship Education*. Routledge Focus on Team Academy. Abingdon: Routledge

Vettraino, E. & Urzelai, B. (2022). *Team Academy: Leadership and Teams*. Routledge Focus on Team Academy. Abingdon: Routledge

Wilson, F., Kickul, J. & Marlino, D. (2007). Gender, entrepreneurial self–efficacy, and entrepreneurial career intentions: Implications for entrepreneurship education. *Entrepreneurship Theory and Practice, 31* (3), p.387-406.

Zimmermann, V. (2016). *SMEs and digitalisation: The current position, recent developments and challenges.* KfW research.

Chapter 7

Blockchain Applications in the Digitization Processes of the Tourism Sector

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Abstract

Blockchain Technology is starting to have an impact in multiple industries, mainly due to its structural characteristics based on security, transparency, and privacy. The application of this innovation in areas such as cloud storage, patent management and property registration, voting and electronic governance, is already relevant. In the tourism sector, the suitability of the blockchain is also evident. This is partially explained by the fact that traditionally this industry has been a pioneer in introducing new information and communication technologies, specially in key areas such as the reservation of flights, hotels, and other accommodation. The huge materiality of the tourism sector both in economic and social terms, demands further analysis of the benefits and opportunities that may derive from the use of Blockchain Technology.

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This chapter offers a bibliographic review of 192 articles identified mainly within the WOS and Scopus database during the month of January 2022, aiming to analyze the main advantages this innovation can bring while acting as a disruptive factor in the tourism industry. These pages also seek to recognize future lines of research on the Blockchain and Tourism binomial.

Keywords: tourism, blockchain, e-tourist, tourism value chain, smart contracts, tourism intermediaries, tokens, smart tourist, IA, bitcoin

Introduction

The tourism sector and the development of new technologies have historically been related. Many of these, including the Internet, have facilitated the generation of new business models (Standing et al., 2014) throughout the entire value chain of the tourism industry.

The adoption of new technologies, has granted end users better access to information and has provided greater transparency in the markets, leading to disruptive changes in the configuration of the tourism sector. Due to the use of the so-called Web 1.0, the Web 2.0, and now what is known as Web 3.0, a consensus has been reached in coining a term to highlight this evolution for the sector: e-Tourism (Eftekhari et al., 2010). The use of this new term is further supported by the incorporation of artificial intelligence and the 5G infrastructure. All in all, it is clear that tourism and technology combines to play an important role in the post-COVID-19 context. Also, in a time when there is an increasing concern for the sustainability (Martín et al., 2018; Salinas et al., 2022), digitization, and increased competitiveness and resilience of the tourism sector (UNWTO, 2021b).

This chapter aims to ponder how Blockchain Technology (Blockchain) can help better the competitiveness of the tourism industry. To reach this goal, the remaining of this chapter is organized as follows. First, we contextualize the blockchain and its advantages. Second, we evaluate its importance within the tourism sector. Third, we introduce a series of research questions based on existing academic literature. Fourth, we review the present and future applications of the blockchain and its contribution to the tourism sector. Fifth and last, we discuss the findings and conclude with a series of conclusions and proposals for different lines of future research.

Approximation to Blockchain

What Is the Blockchain?

The blockchain has attracted a lot of attention since Nakamoto's 2008 paper introduced Bitcoin. From that time on, the "Cryptoeconomics" paradigm has evolved, albeit Nakamoto warned repeatly that bitcoin is not a cryptocurrency. However, the epitome cryptoeconomics has labeled an economic transaction system that utilizes cryptographic hashes as computational proof mechanisms within a software network to transfer and confirm the transmission of assets such as electronic cash, smart contracts, and other. The Bitcoin Blockchain, as well as some of the other blockchains created thereafter, replace the necessary trust that has been traditionally deposited in a third party such as a bank, by the use of a series of tools that turn these central organizations dispensable. In short, this technology replaces trust in human actions by trust in software algorithms that make the economic system more solid and trustworthy (Swan, 2015).

The blockchain is a distributed ledger that combines a consensus protocol with an append-only data structure resistant to modifications. The blocks that form this innovation store the information of a "system" and the "service" that such system grants. Each of the transactions stored includes data such as: the sender, the receiver, the time, the type of asset, and the amount of the asset. The service may be orders to transfer crypto-tokens, or "smart contracts," that is, execution orders that initiate an action when certain conditions are met. For instance, these may require a signature to start the payment of an invoice (Porras et al., 2022). In the chain, the blocks are linked to each other with a cryptographic hash function that ensures these stay unaltered. The chain elongates with new blocks as the network running the consensus protocol agrees on the truthfulness of the transactions contained in them. These nodes or miners, keep an updated copy of the blockchain and receive fees for their work (Porras & Sánchez, 2022).

A short list of key characteristics that provide value to this technology includes the following (Porras et al., 2022):

- A computational logic that can be programmed easily to trigger transactions.

- The irreversibility of records, so that transactions entered update the chain in a way that these records stay chronologically organized, unaltered, and available to anyone in the network.
- Direct peer-to-peer transmission, in that operations and exchanges take place directly between the interested parties.
- The quality of the distribution of the database, so that no single or small group of nodes controls any part of the information. Also, so that any and all parties in the network access the entire database and can verify the records without the intervention of an intermmediate third party. This also ties in with the fact that the programming language remains open source, so it can be scrutinized at will.
- Pseudo anonymity to ensure the flows of transactions between blockchain addresses can be followed-up, if necessary.
- The level of security which is obtained by the use of private keys, cryptographic techniques, and the universe of the large numbers.

Each of a blockchain's characteristics has implications. For instance, Bitcoin delivers a notion of discrete time due to the 10 minute delay between minted blocks. This property may facilitate "abortion of operations," a feature which allows a machine to reconsider an earlier decision upon receiving additional information, as well as the punishment to such "aborting" machines to ensure halt when it cannot reach success.

Table 1. Blockchain groups

Public	*Permissionless*	The consensus mechanism is performed by miners, but it is open to all who wish to participate and have the necessary equipment.
	Permissioned	Anyone can transact and see the transaction log, but only some can participate in the consensus.
Private	*Permissionless*	Restricts who can transact and see the transaction log, but the consensus mechanism is open.
	Permissioned	The consensus mechanism is done by one organization. The owner of the blockchain decides who participates in the system and how.
Consortium	*Permissioned*	The consensus is done by a set of selected nodes. Given consortium ledgers are usually governed by an association of companies there is no competition among the nodes, often no block reward, and usually nodes are controlled by the association, resulting in a high degree of centralization.

Source: based on Porras et al., 2019.

Given the evolution in the blockchain sector, currently, there are many types of blockchains with different characteristics. Hence, it is important to realize that these provide disparate services and assurances, depending upon the consensus protocol used, the transparency of their protocols, and the level of centralization of the network. Table 1 provides a summary of various blockchain groups (based on Porras et al., 2019).

Considering the descriptions in Table 1, we have to realize that even though we use general definitions to describe a blockchain, each specific technology will deliver value according to its own protocol or white paper. We are referring to Bitcoin, probably the better known blockchain, when we define it as a digital ledger or registry published and shared between peers, and maintained by a community of nodes distributed over a network. This ledger is automatically updated as operations that occur between two parties are verified.

What Is the History and Essential Aspects of the Working of Blockchain?

Through history, there had been multiple attempts at creating digital cash. Nonetheless, these had failed mainly because their creators could not offer solutions to the double spending problem and the Byzantine generals problem. In this contex, the former refers to the possibility of spending the same money more than once, when using digital files that represent money; while the latter, points to the difficulty of reaching consensus among parties who do not trust each other. The success of the Bitcoin Blockchain rests to a large degree on Nakamoto's use of a) public key cryptography, b) peer-to-peer networking and c) a proof-of-work to deal with these issues.

Cryptography is the creation of techniques for data encryption to keep messages confidential. When a message is encrypted only those with the key to decrypt would be able to read it. Encryption is used to demonstrate the parties of an operation are who they say they are. So encryption is used as an authentication method. For instance, to initiate certain processes we need to use the digital signature that associates identity to the message. This signature requires two keys: one private and one public. We use the private key (the only one we know) to encrypt, demonstrating it is us and the other party uses the public key to decrypt.

An algorithm is a mathematical formula that determines how the encryption/decryption of the message will be performed. Algorithms are

designed around the assumption of "computational toughness," which means the system cannot be broken because, in practice, there are no known means of accomplishing this task. That is to say: easy codes can be broken in seconds, but breaking difficult codes could require an unlimited amount of resources, such as computational capacity and time.

But how are these algorithms used in the blockchain? Bitcoin works with SHA256, which translates as: 256-bit Secure Hash Algorithm. The hash is a cryptographic procedure where an algorithm is used to transform certain information (for example, a text) into a unique and fixed-length alphanumeric sequence that works like a fingerprint in the sense that it certifies that "what it is, is real." A "hash" results from a function that transforms any input value into an output value. For example, the SHA256, would transform: "tourism" into: 8bd0f4bb7d222c5a808c14ccee156dc0e0ec82ceb3811d628572de3783718223. And anyone who inputs "tourism" into that hash, will obtain the same output. However, should they write "Tourism," they will get this other one: 982cddb36b11000ecd379464e0b1f416f3f3486e11625623c2ef7addc765f45c.

Thus, hashes represent the current state of the world, so the input is the full state of the blockchain: all transactions that have taken place so far. The resulting output hash represents the current state of the blockchain, so the hash is used to ensure that there is agreement between all parties to that the state of the world is the same.

Any mathematical hash function is defined by these three properties: 1st. its input can be a string of any size, 2nd. it produces a fixed-size output, and 3rd. it can be calculated efficiently. Nonetheless, cryptographic hash functions require additional properties. We will not get into those here but it is important to understand that the Bitcoin blockchain uses the SHA-256 hash algorithm to generate verifiable "random" numbers in a way that requires a predictable amount of processing effort.

But how are these hashes actually calculated? The first hash is calculated for the first block, the Genesis block, using the transactions within that block. After Genesis, the hash for each new block that is generated includes the hash of the previous blocks, as well as the transactions in the current block. Each new hash of each block points to the block hash that came before. This is how a chain of blocks is formed and this is how the system ensures that a true record of transaction history is kept. Any changes in the records of the transactions would result in a totally different hash which would affect all the following blocks, just as we showed in our hash example. Thus, record tampering becomes quite easy to detect as it only requires the comparison of the hashes.

Like handwritten signatures, digital signatures are used to prove that messages originate from a certain entity. The main difference is that in the cryptographic context digital signatures are more secure because they cannot be easily forged. Therefore, the blockchain works in part because hashing and digital signatures provide the technology that allows everyone on the blockchain to agree on the state of the world and ensure that transactions are carried out by the legitimate owners of the accounts.

However, given computers are so fast these days, theoretically one could manipulate a block and recalculate all the hashes of the other blocks so that one's blockchain is valid. This is because hundreds of thousands of hashes per second can be estimated. To mitigate this possibility, blockchains have an additional feature: the Proof of Work (PoW) mechanism that slows down the creation of new blocks (Nakamoto, 2008). Here, PoW consists of the obligation to make a certain computational effort that entails a high cost of time for the central processing unit of a computer (CPU). This consumes a lot of energy and hence implies a large investment. Therefore, anyone attempting to corrupt the records, would have to incurr in huge costs in exchange for a nil chance of becoming successful. This PoW is also the mechanism used to decide what the next block should be. This situation arises naturally when transactions are simultaneously checked by multiple nodes which validate and organize them into blocks, affecting the order in which they arrive.

The third component used by Nakamoto was peer-to-peer networking (P2P). This refers to the fact that operations are done peer-to-peer. That is, Alice sends directly to Bob a given amount of bitcoins in exchange for a product or service. Once this operation happens, it is sent to a network of nodes using the same software, the protocol to communicate with each other.

In the Bitocin blockchain, all the nodes are equal to each other, resulting in a distributed system resistant to computer attacks, failures, or falsifications. The reason is that no node or group of them, has filter power over the information that is transmitted in the network. That is: no node has veto power, no node depends upon another node, and no node is more influential than any other one. Consequenlty, if one failed, those to whom it was connected could be reached by alternative means. So, the disconnection of a node never isolates any other node in the network, and no node has the ability to filter what information circulates through the network, or what information reaches the other nodes in the network.

How Does the Blockchain Work?

There are many types of blockchain, but to explain how it works, let us focus on the original blockchain, which is the system that uses bitcoin.

Suppose Alice wants to transfer 3 bitcoins to Bob. Alice has a "digital wallet." This is used by Alice to work with her Bitcoin account which takes the form of a cryptographic "public key." The string of numbers and letters is something like: "1DSrfJdB2AnWaFNgSbv3MZC2m74996JafV."

This key is generated by the Bitcoin software. To "sign" transactions, this account number is associated with a private key under the control of the account owner, Alice here. Therefore, the private key signature serves to confirm that the transaction is legitimate, since it originated with the actual owner of the public key. Then, to forward the money, Alice communicates to the network the transfer of 3 bitcoins from her public key to Bob's. After Alice signs with the correct private key signature, the transaction is complete and irreversible.

Because each node that receives this notice updates its copy of the blockchain ledger and then forwards it along with the transaction message, the process is automatic and transparent: everyone receives a copy of the transaction message at the time each transaction is initiated. Miners pack this transaction together with others in a block and verify these are legitimate by performing the "PoW." Verified operations are added to a block until the block is completed and sealed. To secure the process each new block contains a "hash" which works as a unique identifier of the previous block and links the blocks together. Hence, blocks are linked to each other to guarantee no falsification of records occur.

Given operations are done peer-to-peer, signed, verified, and secured with the unique keys, broadcasted to the whole network, verified by multiple nodes, and included in blocks which form part of a chain that cannot be manipulated, this technology does not require any "trusted" third party to intermediate, authorize, or verify operations.

Blockchain Use, Smart Contracts and Decentralized Autonomous Corporations

At the operational level, blockchain is a type of technology that can be harnessed to create enormous business and social value (Werback et al., 2018). This is partially due to the characteristics of security, transparency, and

privacy of this innovation (Deloitte, 2016). That is why, even though after Nakamoto's 2008 paper speculative projections assured the largest beneficiary of this technology would to be the financial industry, currently, its application outside the banking sector is much more frequent. Now-a-days there are multiple applications in tracing of processes, voting and electronic governance, and all types of Smart Contracts among other (Porras et al., 2019). Specifically, with respect to the tourism sector, even though the academic literature is still not large, it is increasingly becoming an emerging topic.

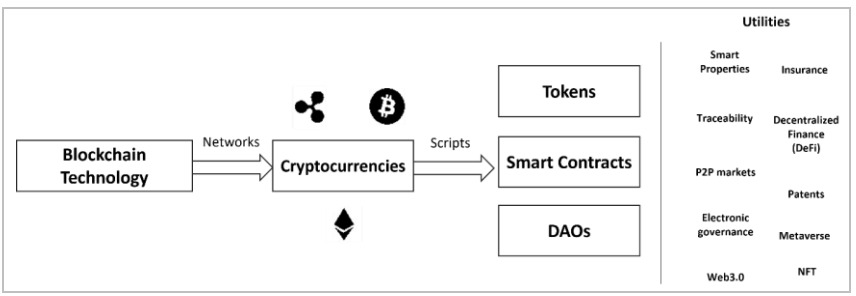
In recent years, numerous pr ojects are using the blockchain through the development of so-called Smart Contracts (Rashideh, 2020). These contracts were defined by Nick Szabo (1994) as a 'computerized transaction protocol that executes the terms of a contract'. The implication is that a set of instructions will be automatically executed when the conditions specified in the contract are met. For instance, a payment may be initiated when a signature is obtained. Among the current and potential applications of Smart Contracts are the management of multisignature electronic wallets, the management of insurance, and inheritance.

Smart Contracts can be executed by natural or legal persons or directly by virtual machines. In the latter case, the evolution of Smart Contracts will reach new heights with the use of Decentralized Autonomous Organizations (DAOs). The DAOs are organizations structured through the blockchain and developed under the Turing Complete system (Petzold, 2008), that function effectively as a single self-managed system or as a platform under certain protocols. Usual applications include the receiving and managing of donations by charitable organizations, the use of platforms to manage grants, software subscriptions, or social networks, as well as the management of virtual properties in the metaverse, such as with Decentraland (Al-Jaroodi & Mohamed, 2019). In the world of finance, some initiatives such as the one undertaken by the European Investment Bank (EIB) to issue the first digital bond (EIB, 2021) are already working.

Blockchain Use in Various Industries

The uses and applications of DAOs are broad. This will include, for instance, the management of the value chain of the different industries, the management of reservations and contracts in the tourism sector, or as an improvement over the transparency and security, in governance and processes of public administrations. To contextualize the relevance of this technology, data taken

from Icobench, one of the main platforms that is responsible for qualifying DAO releases worldwide, shows a total of 5,728 registered platforms and published projects. These include 192 platforms in the tourism sector (Iconbench, 2022). Thus, although there are still few studies on the impact of the blockchain on the tourism industry, some suggest this sector should focus on the creation of new tourism products and systems (Al-Jaroodi & Mohamed, 2019) just as this gradual trend has been observed in the different economic sectors (See Figure 1). Examples include, benefits to the finance, health, logistics, entertainment or agriculture sectors.



Source: Own elaboration.

Figure 1. The universe of blockchain summary.

Because this novel technology is such a promising development, the investment into the sector continues to grow. At the end of January 2022, the global cryptocurrency market capitalization (top 100 cryptocurrencies ranked by market value) exceeded $1.67T (Coinmarketcap, 2022). At an economic level, according to the consulting firm PwC, the 'Blockchain could boost the global economy US$1.76 trillion by 2030 through raising levels of tracking, tracing and trust' (PwC, 2020). As of now, it seems that 2025 will mark the turning point when the blockchain will become a large-scale implementation technology. The same study (PwC, 2020) lists different key applications it will have, such as tracking and tracing of goods and services, new means of payment in the financial sector, identity management, automated contract execution, or conflict management and customer loyalty.

Given the tourism sector has historically made a rapid incorporation of information and communication technologies (Cai et al., 2019) and that practically all the applications detected are key to some part of the value chain of this sector, it appears likely that the blockchain could play an important role in this sector.

The Tourism Sector: Importance and Perspectives

In the last 70 years, the development of technology applied to tourism and the improvement of the general standard of living of consumers have both contributed to the development of the tourism market worldwide (Guaita et al., 2020). For instance, in 2019, 1.5 billion international tourist arrivals were registered globally. However, even though the global tourism sector has grown by 4% in 2021 as compared to 2020, the current figures are still 72% below pre-COVID-19 pandemic levels (UNWTO, 2022).

For a better understanding of what the tourism sector means and its economic and social impact, it is necessary to comprehend its scope (Martín et al., 2019). In other words, one has to undertand its structure, and how its value chain is configured.

In Spain, the Ministry of Commerce, Industry and Tourism defines the tourism value chain as a "form of organization of the tourism sector that integrates the providers of all the products and services that are part of the tourist experience, from the planning of the trip, and the permanence in the tourist destination, to the return to their place of residence" (Diazgranados et al., 2011).

Considering the tourism sector in all its extension, it is clear that the technology available impacts the whole set of actions necesary to start the process of providing tourism services. This includes hotel services and associated vacation rentals, the provision of food and beverages, passenger transport and the services associated with transport, travel agency includingtravel reservations, cultural, and sports and recreational services, in addition to other services not directly related (INE, 2020). Additionally, all the endowment and regulation of the different public bodies should be considered (Martín & Guaita, 2020). A partial list would incorporate the legal framework, the tangible and intangible infrastructures and the activities of organization and public promotion of tourist destinations (Garzan, 2013).

Methodology

Through a review of the academic literature published to date, this chapter seeks to answer two research questions (RQs). These try to evaluate the impact that Blockchain Technology could have in the entire value chain of the tourism industry:

RQ1: What are the main advantages offered by the blockchain to the tourism sector?

RQ2: Can the blockchain act as a disruptive vector in the tourism industry?

After formulating the research questions, the eligible articles have been selected from the Web of Science (WOS) and Scopus databases. In addition, the Google Scholar database was also used, focusing on the 10 most relevant articles ordered by the aforementioned source. The search was carried out throughout the month of January 2022 and the terms used were: 'tourism', 'tourist', and 'Blockchain'. The initially identified articles were screened thereafter, to exclude those that (1) were not peer-reviewed, (2) those whose theme was not related to the defined keywords, and those (3) that were not written in English or Spanish language. Finally, we also excluded (4) those that were not classified as a paper or book chapter. Because the nature of the search is quite novel, the publication date criterion was not used to assess the relevance of the information. The reason is that most of the publications post date 2018.

After this initial screening, 192 publications were located (WOS 132; Scopus 60). This list was further reviewed to exclude duplicate articles and those whose theme and conclusions were too general or similar to some other of the included articles. In addition to these sources, different relevant working documents and contrasted news were used as a source of information for this chapter. Between articles, working documents, and news, a total of 65 bibliographic resources were selected. These constitute the main source of this bibliographic review. Rather than formulating hypotheses, in this chapter we intend to contribute to the construction of a conceptual framework of the relationship between the blockchain and the tourism sector, providing a structure that support specific lines of future research.

Blockchain Contributions to the Tourism Sector

Over the last decades, a few technological advances have had a major impact on the tourism industry, either due to the appearance of cheaper travel alternatives or to the emergence of new markets (Sigala, 2018). In this sector, the appearance of new technological actors has generated a process of destruction and creation of value. And lately, the blockchain has had an impact on the efficiency gains and growth expectations of numerous business

activities. Of course, the tourism sector is not foreign to this digitization process, its consequences, and impacts. However, historically, the tourism sector has been a technology-adoption pioneer. Therefore, it is important to ponder what may result as a consequence of the absorption of blockchain technologies throughout the value chain of this sector.

In tourism, some of these technologies are still in the experimental phase of the introduction, such as it is the case of augmented reality, or the internet of things (IoT). Although there is evidence that they are creating opportunities by improving the promotion of destinations or the productivity of the business segments involved.

The use of technologies such as IoT, services based on geolocation, artificial intelligence, augmented and virtual reality, or the blockchain, would be giving rise to a more attractive, efficient, inclusive, and sustainable offer from the economic, social and environmental points of view. In addition, these technologies would also be facilitating the improvement of processes that help respond to challenges such as seasonality and over-exploitation of tourist destinations (Martín et al., 2019). This process of technological improvement and digitization can cause a real revolution when it comes to facilitating smart travel. In fact, it may have such an impact, that it is already associated with the creation of new job profiles (UNWTO, 2021a; UNWTO, 2021b). In an attempt to answer the above research questions, throughout this chapter we will present a list some of the benefits that Blockchain Technology could offer this sector. In addition, we will also review opportunities this sector could enjoy if it follows comparable paths to others as well as potential applications and future developments.

Tourism Industry Involved

At a theoretical level, the application of Blockchain Technology to the tourism sector, promisses great benefits to this industry. Whether it issupporting sales transactions, facilitating the operations of various parts of the value chain, improving the payment system or in the development of smart destinations, all these procedures would be eased and made more efficient

With respect to the value chain of the sector, the use of the blockchain would affect the disintermediation processes of the entire tourism industry (Rashideh, 2020). For instance, the food and agriculture sectors are particularly fit to benefit from the traceability solutions which help ascertain the history of food supply, demand, and delivery optimizing the quality and

safety of the processes at all stages of the value chain. This is just one example of the many opportunities that may result from the integration of blockchain in the operations of the economic systems involved.

The adoption of the blockchain will changethe way in which companies establish relationships with suppliers, key partners, and end customers. In addition, this technology will also affect the management of the sector's assets such as passengers, hotel beds, and transport units. In doing so, this technology will accelerate and expedite transactions, eliminate the possibility of fraud or duplication in operations and, ultimately, strengthen the system and improve the communication between the parties.

With respect to passenger mobility, the Blockchain and Smart Contracts identifier tokens will be used to resolve bottlenecks generated in transport infrastructures (IBM, 2018). In addition, the uniquely identifiable token could be used to improve the customer loyalty system once the trip is over using this. With respect to the management of the sector's human resources, this technology could help in the authentication of the personnel increasing the security of the system and minimizing the possibility of falsifying identity cards, and documentation such as the necessary licenses. In reference to transport assets (automobiles, aircraft, spare parts, etc.), traceability could improve the purchase and use of the said assets or in the processes of maintenance including the renewal of parts and status of revisions (SITA, 2021). Of course, these opportunities are extensive to other segments such as the food industry or freight transport.

Analysis by Area of Tourism Activity

In this chapter, we identify eight segments or areas of interest based on their relative importance: the key advantages the blockchain provides, their use in the tourism sector, and the leading cases detected. This list also highlights a series of prime opportunities and challenges for the tourism sector.

Online Tourist Agencies

Online Tourist Agencies (OTAs), are platforms that offer the possibility of booking trips, accommodation, transports and other associated services. For example, Winding Tree (https://windingtree.com/) is a marketplace that allows the decentralized distribution of offers from different tour operators. This is one of the largest blockchain-based networks directly connecting buyers and suppliers to reduce the cost in the distribution of products and

services. This company is also developing new business models in tourist segments that were previously not being served, such as leisure trips for corporate clients. Smart Contracts allows this application a to collect data thereby ensuring the ownership of superior customer information. Within the accommodation reservation platform of another application, Travala (https://www.travala.com/), this company offers a payment system in different cryptocurrencies, through the Binance and Crypto.com exchanges. Also, since 2017, it has " AVA," a token which allows travelers to book stays, flights, and other activities associated with traveling. This includes an incentive program based on blockchain which offers discounts and loyalty rewards (Travala, 2021).

Another offer is that by he online travel agency Webjet (https://www.webjet.com.au/), which works on reservation verification solutions through the Rezchain platform. This agency has taken control of a company for tourist reservations that works with various tourist asset tokens. Its promise is to generate lifetime financial liabilities for its owners with up to a 3% return through staking. In addition, it has also entered the Non-Fungible Tokens (NFT) market.

Yet one more example is the Travelport platform (https://www.travelport.com/) which, in partnership with IBM, is developing a blockchain-based solution to speed up the payment of commissions between hotel establishments and the travel agency BCD Travel. Their aim is to ease the information transfer between the parties involved in hotel reservations, avoiding manual data management, reducing operating costs, and the possibility of errors.

Finally, the TravelCare travel platform (https://travelcare.io/es/) considers itself the first online travel agency to incorporate a rewards program based on Blockchain Technology. This company offers end users the possibility of accumulating a token to receive discounts on their different vacations, flight and hotel services. It also incorporates the possibility of performing staking operations to earn rewards. The advantages it offers are based on cost reductions resulting from reduced brokerage fees, increased efficiencies, and lowering commissions on international payments. Many other initiatives related to online travel agencies have been launched in recent years (Irannezhad & Mahadevan, 2021), although few still survive today.

Airlines

In the airline and flight market, the Loyyal (http://www.loyyal.com/) solution enables loyalty systems to be established to attract and retain infrequent

travelers. This is achived by increasing the efficiency of operations and the quality of the service given to the customer, hence enhancing the value perceived by customers (Gunter & Önder, 2018; Önder & Gunter, 2020).

In this case, the airline could associate its service with other road transport services such as Lyft or Uber to offer a rewards program for the use of these services. This concept could in turn be replicated in dozens of other collaborations in sectors such as food, fashion, or electronics. The typical latency of weeks or months that it takes to transfer of information about the rewards between allied companies, is solved through the execution of a Smart Contract based on blockchain. This allows a faster implementation of the loyalty program and the generation of more complete information with respect to customer behavior, reducing costs and operational complexities. Under the same principle, this solution could be incorporated into other parts of the airline value chain. Some examples are baggage tracking, control of passenger check-in and boarding documentation, or traceability of food and beverages that enter on board. Of course, this extends to the bar and restaurant activity of the industry.

Various airlines such as Lufthansa have shown great interest in implementing the blockchain to help in their internal management processes. Some examples arethe check-in and boarding processes or baggage management.

At the airline industry level, the International Civil Aviation Organization (ICAO) leads the Blockchain Sandbox Project[1], which aims to digitize various aviation industry records using the blockchain. These include pilot log records, aircraft maintenance, passenger registration, and financial transactions. Through the development of a universal identification system for access to airport facilities and aircraft he aim is to minimize the impact at the time of the possible falsification of documentation associated with aircraft, pilots, and passengers.

Another project is to streamline the aircraft licensing system between the different air authorities, also adopting blockchain solutions as a regulatory tool (ICAO, 2019; ICAO, 2020). In this sense, the provider of technological services for transport SITA maintains different undertakings, some of which are in collaboration with organizations such as ICAO. For example, in collaboration with some airports and airlines, SITA has published a working document called FlightChain[2]. This report describes the uses of Smart

[1] https://www.icao.int/about-icao/partnerships/Pages/Blockchain-Sandbox.aspx.
[2] https://www.sita.aero/resources/White-papers/flightchain-shared-control-of-data.

Contracts in terms of improving the safety and reliability of aviation processes in this sector (SITA, 2017). Among other, this document identifies opportunities in the areas of shared data control even when it is recognized that blockchain still has a long way to go, for example, in terms of regulatory needs for approval by regulatory bodies such as ACI or IATA.

Another area of interest is possible paths to technical viability. A business model of all the decentralized developments can be found in the GitLab FlightChain repository. This company is already offering secure air registration solutions based on blockchain, allowing airlines to verify pilot licenses without the need for a network connection.

Also, Shocard and SITA have jointly developed the SITA Digital Traveler Identity. This software enables the identification of travelers at the beginning of their trip, without the need to be identified at each of the control points during their travel process (Sita & Shocard, 2016). This application guarantees the privacy of the personal data of the travelers at all times, and it prompts the question of a universal unique travel token based on blockchain, which is secured and stored in any mobile phone.

Another tool is the Trustabit Platform3. This solution offers the possibility of notifying passengers of flight delays in real time. It also works on loyalty programs for airlines by issuing of digital coupons for restaurant and transportation services, with the promise of improving the passenger user experience. These services are all operated through the issuance of Smart Contracts based on blockchain (TrustaBit, 2022).

Tour Operators

TUI Group has recently launched a blockchain solution based on a Smart Contracts system that can manage hotel bed inventory and capacity in real time through a global database. This app helps reduce the costs of reservations and improves the efficiency of these processes. The project is known as Bed-Swap (Tui Group, 2017).

Amadeus has also been working on incorporating blockchain into the fields of loyalty, baggage tracking, identity verification and, in general, the travel value chain (Amadeus, 2017). Due to the pandemic caused by COVID-19, this company has implemented the IBM Digital Health Pass system from IBM together with some airlines. This solution uses blockchain to authenticate the so-called COVID passport. Specifically, airlines receive confirmation that the passenger is ready to fly from a health point of view, not sharing any other

[3] https://www.trustabit.io.

health information with either party (IBM, 2021c). As far as mobility is concerned, the hi+Card application4 offers travelers the possibility of always having all their medical information at hand, using blockchain to guarantee the control and data protection, functioning as an international health card (Hicard Travel, 2021). This technology could be implemented throughout the tourism service provision chain by tour operators.

Hotels and Accommodation Industry

In 2017, the Taiwanese company Owlting launched a service called OwlNest Blockchain Hotel Management Service, the first hotel establishment management service based on Ethereum network protocols. Through the use of Smart Contracts on the inventories and the reservations, this application manages the reservation engine and the properties of the establishments; hence, ensuring the privacy and security of the transactions (OwlTing, 2022). This solution facilitates a more efficient management of the costs of hotel establishments and improves loyalty programs, reducing the establishments' seasonality.

One of the most promising applications in this segment is Modihost, a solution which combines the blockchain with artificial intelligence to enhance the hotels' ability to predict customer the needs. By issuing tokens, the combined technologies can be used to increase sales and the cross-selling of the establishments, as well as the automation of routine tasks. In addition, the platform has an ambitious roadmap with goals to be achieved (Modihost, 2019). In this sense, the results of research showing the positive impact of blockchain on consumer behavior has already been published (Wang et al., 2021) showing the betterment of business marketing and consumer confidence.

Maintenance, Repair and Operations

The air transport industry assumes an average of US$50,000 million in expenses for aircraft spare parts each year (Aviation Business News, 2021). One of the challenges faced is tracking and locating parts. This continues to be organized in such a way that it requires a large number of manual processes, without the existence of standardized global traceability systems, thus producing an increase in expenses related to data management, also generating risks of duplication and overlapping of data. SITA has prepared a white paper for the MRO industry (SITA, 2021) that aims to provide solutions so that

[4] https://www.hicard.travel/.

airlines can face these aforementioned challenges in terms of aircraft maintenance activities. This process affects both buyers, engineers and administrators of spare parts and maintenance management. The solution promises to provide a digital 'birth certificate' for all parts installed on an aircraft, updateable each time the part is repaired or inspected.

In this sense, the Block.aero platform offers a digital certificate solution already in operation for the MRO industry that promises to improve trust between parties involved, eliminating repetitive data reconciliation and transfer errors, in addition to promising improvement in standardization of internal processes (Block.Aero, 2021a). This same platform maintains collaborations with other organizations such as the ICAO, for the development of a solution based on blockchain that will help respond to possible air crises and reduce the risks of natural disasters (Block.Aero, 2021b). Also noteworthy is the role that the Blockchain in Transport Alliance (BiTA) has played in recent years, which aims to create universal standards in transport and logistics based on blockchain (BiTA, 2017).

P2P Tourism Platforms

In the case of the short-term housing rental market for tourism through P2P platforms, the first blockchain profits have already been raised, boosted by the opportunities that arose after the end of the COVID-19 pandemic. One example, is the School of Estate Registrars of Spain which in 2019 announced the launch of a service to register properties for tourist use based on the blockchain. This technology helped the auditing of these services reducing the risks of fraud in the sector, while permitting the use of the P2P platforms for its implementation. Some studies (Comelles, 2020) have already raised the need to improve the regulation of this business segment using blockchain-based platforms through the 'toketization' of the industry.

Recent studies have dealt with an approach to P2P collaborative economy platforms. These works have focused on the concern to guarantee the security of the data on these platforms (Veloso et al., 2019). Here, different research scenarios are proposed, ranging from the impact of false information hosted on the platforms, to models to guarantee the reliability of the information contained, which could be solved with the blockchain. Brian Chesky, the CEO of the largest P2P platform for the marketing of homes for tourist use worldwide, revealed at the beginning of 2022 that the possibility of making the payment with cryptocurrencies on the platform was the most important suggestion from users. Chesky himself replied: 'Already working on most, will look into others now!

Tourist Destinations

Due to the rapid adoption of the blockchain in various economic sectors, many opportunities are being generated. But, of course, for the tourism industry, there are also challenges that also affect public administrations in terms of its regulation, introduction of new forms of payment, improvement of efficiency of the value chain, or the use of technology as a way of promoting destinations.

Since September 2021, El Salvador has become the first country in the world to adopt Bitcoin as legal tender in the country. The main objective declared was to reduce the financial costs of the economy and attract foreign investment to lever for domestic consumption (New York Times, 2021). For now, it appears that the plans are not coming through as expected, having linked part of its bond issues to the price of digital currency, which could cause risks of default on public debt in the future. Matters such as assuming the risk of the exchange rate due to fluctuations in Bitcoin, overcoming technical barriers (internet access or smartphone market), the real capacity to meet the needs of citizens, or the continuous renewal regulations to prevent the use of the technology in the financing of illicit activities are fair concerns (Gorjón, 2021). So, we shall have to wait a little longer to see the evolution of this technological adoption and the entire proposed ecosystem.

The background of the introduction of blockchain in the tourism sector dates back to the actions carried out by regions and islands in Thailand and Greece, which began to accept Bitcoin as forms of payment in 2014. In 2017, the island of Aruba undertook an initiative to implement a tourism distribution platform, connecting hotel establishments with potential customers from various airlines through an Etherum-based network, which aims to reduce the brokerage fees paid by hotels to intermediaries (Zupan, 2019) and that is in the experimentation phase. The Caribbean island Bequia has launched the One Bequia project, which aims for residents and visitors of the island to pay for their products, services and even properties through the use of Bitcoin (Martínez, 2021). This is proposed as a challenge to the competition and fees of the large international banks and to deal with the practice known as Deriesking, through which large financial corporations eliminate their collaboration with local community banks to carry out international transactions.

At the regulatory level, various European countries are developing a framework for the use of blockchain. In 2018, Malta passed a series of laws regulating different virtual currencies and services on said virtual assets, maintaining a proactive regulatory approach. In 2020, Switzerland approved various regulations on said technology and launched the Distributed Ledger

Technology (DLT) project with the aim of increasing the country's reputation at the blockchain innovation leadership level (Ferreira & Sandner, 2021). The Marshall Islands or Puerto Rico are other economies that have taken actions regarding the blockchain (Kwok & Koh, 2019). It seems that there are opportunities to be exploited by tourist destinations to obtain a benefit in terms of improving the experience of tourists or to achieve a more efficient management in the promotion of tourist destinations. Different studies have already been launched to review the impact of blockchain in smart tourist destinations (Tyan et al., 2020) in order to guarantee mutual benefits for the communities involved.

Food and Drink Industry

There are already real case studies on how the blockchain can help manage the agri-food supply chain for food tracking (Baralla et al., 2021), with the promise that it will support the attraction of tourists and the promotion of the area tours. With these solutions it would be the final consumer who could check the traceability of food, especially that which require a cold chain, even checking its origin by consulting a public accounting record based on blockchain. Various investigations show that blockchain can solve problems in providing transparency regarding the traceability of products towards interested parties (Jarka, 2019). For example, IBM has developed the "Blockchain in Food Safety" program (IBM, 2022), where it shows the success stories in the supply chain of the blockchain application in terms of increasing brand trust, security, fraud control and improvement of food waste, demonstrating real applications in the brewing industry (IBM, 2021b) as well as in seafood (IBM, 2021a).

Discussion and Conclusion

The above content sufficiently responds to RQ1: What are the main advantages offered by the blockchain to the tourism sector? The blockchain is presented as a relevant factor to revolutionize many of the economic sectors, including the tourism sector (See Figure 2). Basically, this technology is changing the way information is stored and used, improving the transparency and security of transactions. Unlike the different websites, which store the information at central locations, the blockchain stores the information in a decentralized manner, providing characteristics of invariability and security in

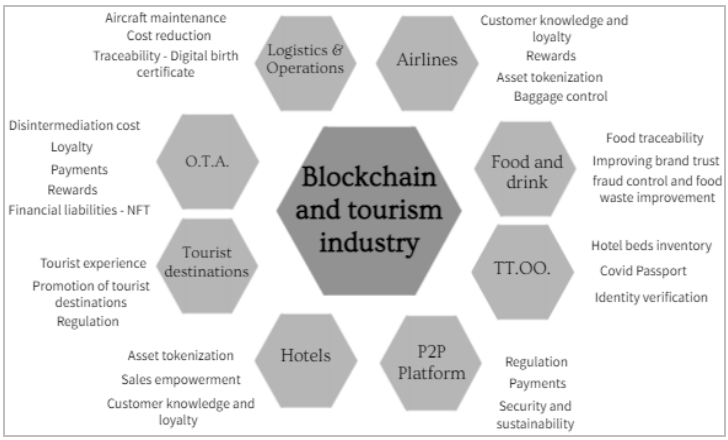
the stored data. From the analyzed data, the possibility of generating immutable tokens associated with cryptocurrencies, the benefits of Smart Contracts when it comes to eliminating intermediaries, and the possibility of creating an identifier for tourist assets, look like the great functionalities that can generate value within the tourism sector in the future. Even though its development and practical application is still in a very early stage of development.

Throughout the development of this chapter, it has been explained how the introduction of this technology in the tourism sector can accelerate the improvement of the quality of the service provided to the final customer, giving the opportunity to get to know him better, lower the costs of intermediation and provide additional services, such as the instruction of compensation programs for cancellations, based on the execution of Smart Contracts under the blockchain.

Cost savings can also come via improved efficiency in waiting times for access to different means of transport, combined with other technology such as artificial intelligence or facial recognition. Another clear example of the blockchain's contribution can come with the development of baggage traceability applications throughout the entire value chain of tourist service provision, giving greater transparency and security to the process. This application is already being used in sectors related to logistics and maintenance for the identification of different pieces and spare parts in the form of digital assets.

The benefits can also reach marketing through the development and refinement of customer loyalty tools. These systems would allow the creation of large affiliate programs capable of generating a reliable and secure environment through the use of tokens associated with customer behavior. And with it, predict future behavior, grant rewards, and resolve conflicts associated with customer service or the quality policy of companies.

One of the most promising benefits that blockchain can exert in the tourism sector is the role of decentralization of tourism markets. Such is the case of hotels, airlines or P2P platforms for short-term rental of homes for tourist use, promising the elimination or reduction of commissions from intermediaries, by being able to use the blockchain so that homeowners and clients or endpoints can connect directly or with less intervention from P2P platforms. At a financial level, the use of the blockchain as a universal payment system could make the movement of financial flows less expensive, simpler, and safer. In addition, the delays caused by the banking and exchange rate markets would decrease.



Source: Own elaboration.

Figure 2. The universe of blockchain summary.

Given the second RQ raised: can the blockchain act as a disruptive vector in the tourism industry? Based on the data provided, it seems clear that the use of this technology by the tourism industry is still at a very early stage of development and application, as is the degree of research regarding its impact on the tourism sector. Considering the degree of adoption of innovations by users (Rogers, 1962), the technology is in a phase of low development used by users called 'Early adopters' of innovation. In this phase, real and practical solutions begin to appear that seek to solve the real problems of the sector. As early adopters and developers help build a useful test bed that can guide the rest of the industry, this could push the rest of the industry to gradually incorporate it into their business processes, which would also lead to greater research need for such technology. Although this technology is still in its early stages of development, its greater generalization could lead to radical changes in the activities of the tourism value chain, impacting the configuration of tourism services, in a sector that has historically always been very receptive to introducing technological improvements. It remains to be seen whether this would truly entail a change in the configuration of power within the providers of tourist services.

Everything indicates that the blockchain will have a relevant role in the tourism sector, in part due to the very configuration of the value chain of the sector in which a large number of intermediaries are involved. Therefore, disintermediation processes are expected to increase as the development of solutions and platforms that incorporate this technology advances. As long as

there is cooperative work in the sector to incorporate this technology. In this sense, new business opportunities may arise for a profile of intermediaries that incorporate blockchain into their business model, replacing traditional intermediaries with those that can incorporate solutions based on Smart Contracts in areas such as finance, inventory management, marketing and passenger identity management. It is to be hoped that as public and private funds dedicated to this technology increase, the opportunities for the tourism sector will also increase. With this, opportunities would be developed for the creation of new tourist services, tourist service providers that incorporate services with lower disintermediation costs, more transparent payment systems and with lower commissions, etc. In addition to safer and more efficient identification systems, related to inventory management in hotel rooms, beds, luggage, logistics assets and complementary services.

Limitations and Future Lines of Research

The tourism sector has traditionally been one of the first to absorb technological advances, either through the appearance of new companies with new, more efficient products, or by reconfiguring markets or tourist destinations. Even though research on the absorption of Blockchain Technology in the tourism sector is still emerging, this chapter aims to serve as a working document to highlight the potential value of this technology, as well as its implications for the entire chain of tourism in terms of opportunities and challenges.

The global implementation of blockchain in the key areas that make up tourism products and services may imply an improvement in the tourist experience, as perceived by the end-user. In addition, it can contribute to lessen problems that have plagued the sector for years. One example is the seasonality of tourist services, which could be deflated with real-time information on tourist destinations or rewards to change dates or locations. These types of actions would go a long way to contribute to the sustainability of the sector helping balance economic, social and environmental concerns. The privacy, inalterability and transparency ob the blockchian can also help reduce the impact that tourism has on local communities, and increase transparency about tourism assets, their legality, and status.

Public authorities and other organizations should incorporate this technology into the sector thorugh long-term strategies to reduce the said weaknesses. And it appears vital to develop targeted research to better

understand the usefulness of this technology to the tourism sector. Some lines of research should evaluate the impact that blockchain initiatives are having within the tourism sector. Specifically, in areas such as improving the tourist experience. Some projects promoting tourist destinations in the metaverse are underway. Knowledge regarding how regulators, companies, and end-users accept and incorporate technology that could contribute to the promotion and regulation of the tourist destination could also be initiated. In this sense, it would be convenient to work on lines of research that can better define the degree of acceptance of this technology in business segments such as P2P platforms or online travel agencies. Furthermore, from the point of view of the end users, it would be interesting to find out if the benefits brought by this technology could lead to an acceptance of the use of said technology. It is necessary to analyze what type of legal framework and infrastructure would be necessary to develop in order to take advantage of all the benefits of technology in combination with another. In addition, it seems relevant to know how this technology could add value to prevent problems such as vulnerability to hacking of personal data, prevention of fraud related to this technology or compliance with data protection regulations in different regions. Therefore, although in this chapter cases have been put on the table that suppose that this technology will be disruptive for the tourism sector, it seems reasonable to wait for future research to be able to analyze its success.

References

10015.io. (2020). SHA256 Encrypt/Decrypt Online | *10015 Tools*. https://10015.io/tools/sha256-encrypt-decrypt.

Al-Jaroodi, J., & Mohamed, N. (2019). Blockchain in Industries: A Survey. *IEEE Access*, *7*, 36500–36515. https://doi.org/10.1109/ACCESS.2019.2903554.

Amadeus. (2017). *Blockchain: harnessing its potential in travel*. https://amadeus.com/en/insights/research-report/Blockchain-harnessing-its-potential-in-travel.

Aviation Business News. (2021). How Blockchain is revolutionising the MRO sector. https://www.aviationbusinessnews.com/mro/how-Blockchain-is-revolutionising-the-mro-sector/.

Baralla, G., Pinna, A., Tonelli, R., Marchesi, M., & Ibba, S. (2021). Ensuring transparency and traceability of food local products: A Blockchain application to a Smart Tourism Region. *Concurrency and Computation: Practice and Experience*, *33*(1), e5857. https://doi.org/10.1002/CPE.5857.

BiTA. (2017). *BiTA: Blockchain in Transport Alliance*. BiTA. https://www.bita.studio/.

Block.Aero. (2021a). *Block Aero – Digitize Your Assets, Launch Your Blockchain*. https://block.aero/.

Block.Aero. (2021b). *Últimos avances entre la OACI y Block Aero sobre reducción del riesgo de desastres y respuesta a crisis* [*Latest developments between ICAO and Block Aero on disaster risk reduction and crisis response*] – Block Aero. https://block.aero/2021/06/11/icao-development/.

Cai, W., Richter, S., & McKenna, B. (2019). Progress on technology use in tourism. *Journal of Hospitality and Tourism Technology*, *10*(4), 651–672. https://doi.org/10.1108/JHTT-07-2018-0068/FULL/PDF.

Coinbase. (2020). *What is DeFi?* https://www.coinbase.com/es/learn/crypto-basics/what-is-defi.

Coinmarketcap. (2022). *Precios, gráficos y capitalizaciones de mercado de criptomonedas* [*Cryptocurrency Prices, Charts, and Market Caps*] | CoinMarketCap. https://coinmarketcap.com/es/.

Comelles, C. A. (2020). Developing P2P accommodation 4.0 when faced with COVID-19: Proptech, self-regulation and Tokenization. *Revista de Internet, Derecho y Politica*, *31*. https://doi.org/10.7238/IDP.V0I31.3225.

Deloitte. (2016). *Beyond bitcoin: Blockchain is coming to disrupt your industry*. https://www2.deloitte.com/mt/en/pages/financial-services/articles/mt-banking-alert-019-Blockchain-is-coming-to-disrupt-your-industry.html.

Diazgranados, S., Viceministro De Turismo, G., García, O. R., Moscarella, J., Fernández, R., Investigación Y Textos Beatriz, Á., Rosas, H. P., & Bravo, A. (2011). *Lineamientos De Política Para El Desarrollo Del Turismo Comunitario En Colombia* [*Policy Guidelines for the Development of Community-Based Tourism in Colombia*].

Eftekhari, M. H., Barzegar, Z., & Isaai, M. T. (2010). Web 1.0 to Web 3.0 Evolution: Reviewing the Impacts on Tourism Development and Opportunities. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *6529 LNCS*, 184–193. https://doi.org/10.1007/978-3-642-18348-5_17.

EIB. (2021). *EIB issues its first digital bond on Blockchain*. https://www.eib.org/en/stories/cryptocurrency-Blockchain-bonds.

Ethereum.org. (2020). *Decentralized autonomous organizations (DAOs)* | ethereum.org. https://ethereum.org/en/dao/.

Etherscan. (2022). *$0.12 | Lif (LIF) Token Tracker* | Etherscan. https://etherscan.io/token/0x9C38688E5ACB9eD6049c8502650db5Ac8Ef96465?a=0x9c38688e5acb9ed6049c8502650db5ac8ef96465.

Ferreira, A., & Sandner, P. (2021). Eu search for regulatory answers to crypto assets and their place in the financial markets' infrastructure. *Computer Law & Security Review*, *43*, 105632. https://doi.org/10.1016/J.CLSR.2021.105632.

Garzan, E. (2013). *Cadena de valor* – Esther Garsan [*Value chain* – Esther Garsan]. https://www.esthergarsan.com/segmentamos-pero-realmente-nos-diferenciamos/cadena-de-valor/.

Gorjón Rivas, S. (2021). Repositorio Institucional: El papel de los criptoactivos como moneda de curso legal: el ejemplo de El Salvador [Institutional Repository: The role of crypto assets as legal tender: the example of El Salvador]. *Boletín Económico* 2021, Banco de España. https://repositorio.bde.es/handle/123456789/18991.

Guaita, J. M., Martín, J. M., & Ostos, M. S. (2020). An analysis of the changes in the seasonal patterns of tourist behavior during a process of economic recovery. *Technological Forecasting and Social Change*, 161, 120280.

Gunter, U., & Önder, I. (2018). Determinants of Airbnb demand in Vienna and their implications for the traditional accommodation industry. *Tourism Economics*, *24*(3), 270–293. https://doi.org/10.1177/1354816617731196.

Harvard Business Review. (2015). *¿Qué es la innovación disruptiva?* [*What is disruptive innovation*] https://hbr.org/2015/12/what-is-disruptive-innovation.

Hicard Travel. (2021). *hi+Card Health Identification Card App*. https://www.hicard.travel/.

IBM. (2018). *Move your transportation operations ahead with IBM Blockchain solutions*. https://www.ibm.com/downloads/cas/JXGEZ0KB.

IBM. (2021a). *Blockchain stories: Giving Norwegian seafood a competitive edge*. IBM Supply Chain and Blockchain Blog. https://www.ibm.com/blogs/Blockchain/2021/07/Blockchain-stories-giving-norwegian-seafood-a-competitive-edge/.

IBM. (2021b). *Brewing a more traceable and sustainable beer industry with Blockchain*. IBM Supply Chain and Blockchain Blog. https://www.ibm.com/blogs/Blockchain/2021/07/brewing-a-more-traceable-and-sustainable-beer-industry-with-Blockchain/.

IBM. (2021c). *Digital Health Pass* - España | *IBM*. https://www.ibm.com/es-es/products/digital-health-pass.

IBM. (2022). *Blockchain in food safety* | IBM Supply Chain and Blockchain Blog. https://www.ibm.com/blogs/Blockchain/category/Blockchain-in-food-safety/.

ICAO. (2019). Assembly-40th Session Technical Commission Agenda Item 30: Other issues to be considered by the Technical Commission Use of Blockchain Technology as a Regulatory Tool (Presented by Brazil).

ICAO. (2020). *Blockchain Sandbox*. https://www.icao.int/about-icao/partnerships/Pages/Blockchain-Sandbox.aspx.

Iconbench. (2022). *ICObench*. https://icobench.com/.

INE. (2020). Cuenta Satélite del Turismo de España (CSTE) [Satellite Account of Tourism of Spain (CSTE)]. *Revisión estadística 2019 [Statistical Review 2019]*.

Irannezhad, E., & Mahadevan, R. (2021). Is Blockchain tourism's new hope? *Journal of Hospitality and Tourism Technology*, *12*(1), 85–96. https://doi.org/10.1108/JHTT-02-2019-0039/FULL/PDF.

Jarka, S. (2019). Food Safety in the Supply Chain Using Blockchain Technology. *Acta Scientiarum Polonorum. Oeconomia*, *18*(4), 41–48. https://doi.org/10.22630/ASPE.2019.18.4.43.

Kizildag, M., Dogru, T., Zhang, T. (Christina), Mody, M. A., Altin, M., Ozturk, A. B., & Ozdemir, O. (2020). Blockchain: a paradigm shift in business practices. *International Journal of Contemporary Hospitality Management*, *32*(3), 953–975. https://doi.org/10.1108/IJCHM-12-2018-0958/FULL/XML.

Kwok, A. O. J., & Koh, S. G. M. (2019). Is Blockchain technology a watershed for tourism development? *Current Issues in Tourism*, *22*(20), 2447–2452. https://doi.org/10.1080/13683500.2018.1513460.

Martín, J. M., & Guaita, J. M. (2020). Entrepreneurs' attitudes toward seasonality in the tourism sector. *International Journal of Entrepreneurial Behavior & Research*, 26 (3), 432-448.

Martín, J. M., Guaita, J. M., & Burgos, A. (2019). Promotion and Economic Impact of Foreign Tourism, *Journal of Promotion Management*, 25 (5), 722-737.

Martín, J. M., Ostos-Rey, M. S., & Salinas, J. A. (2019). Why Regulation Is Needed in Emerging Markets in the Tourism Sector. *American Journal of Economics and Sociology*, *78*(1), 225–254. https://doi.org/10.1111/ajes.12263.

Martín, J.M., Prados-Castillo, J.F., Jiménez, J. de D. & Porras, E. Interferences Generated on the Well-Being of Local Communities by the Activity of Online Platforms for Tourist Accommodation. *Journal of Sustainable Tourism.* December 2020. https://doi.org/10.1080/09669582.2020.1861455.

Martín, J. M., Rodriguez, J. A., Zermeño, K. A., & Salinas, J. A. (2018). Effects of vacation rental websites on the concentration of tourists—potential environmental impacts. An application to the Balearic Islands in Spain. *International Journal of Environmental Research and Public Health*, *15*(2). https://doi.org/10.3390/ijerph15020347.

Martínez, J. (2021). *Bequia busca convertirse en la primera "Isla Bitcoin" del Caribe – BeInCrypto* [*Bequia Seeks to Become the First "Bitcoin Island" in the Caribbean – BeInCrypto*]. Beincrypto. https://es.beincrypto.com/bequia-busca-convertirse-primera -isla-bitcoin-caribe/.

Modihost. (2019). *ModiHost: Whitepaper Ver. 1.0*|.

Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. www.bitcoin.org.

New York Times. (2021). El Salvador adopta el bitcóin y despierta críticas nacionales y la admiración de la comunidad de criptomonedas – [El Salvador adopts bitcoin and arouses national criticism and the admiration of the cryptocurrency community] *The New York Times*. https://www.nytimes.com/es/2021/09/07/espanol/bitcoin-el-salvador .html.

Önder, I., & Gunter, U. (2020). *Blockchain: Is it the future for the tourism and hospitality industry?* https://Doi.Org/10.1177/1354816620961707. https://doi.org/10.1177/1354816620961707.

OwlTing. (2022). *OwlTing Blockchain Services*. https://www.owlting.com/obs/industry/Travel-and-Hospitality.

Petzold, C. (2008). *The annotated Turing : a guided tour through Alan Turing's historic paper on computability and the Turing machine*. 372.

Porras, E, Martín, J. M. & Guaita, J. M. (2019). A Critical Analysis of the Advantages Brought by Blockchain Technology to the Global Economy. *International Journal of Intellectual Property Management*, 9 (2) https://doi.org/10.1504/IJIPM.2019.100214.

Porras, E., Martin, J. M., Guaita, J. M. & Hamoudi, H. (2022). The Disruptive Effect Of Technological Innovation In The Tourist Accommodation Industry. *International Journal of Innovation and Technology Management*, 19 (1). https://doi.org/10.1142/S0219877021400083.

Porras, E. & Sánchez, G. (2022). Decentralized Blockchain for Autobiographical Memory in Cognitive Robotics. *Journal of AI, Computer Science and Robotics Technology*, 1(1). DOI: 10.5772/intechopen.96798.

PwC. (2020). *Blockchain technologies could boost the global economy US$1.76 trillion by 2030*. https://www.pwc.com/gx/en/news-room/press-releases/2020/Blockchain-boost-global-economy-track-trace-trust.html.

Rashideh, W. (2020). Blockchain technology framework: Current and future perspectives for the tourism industry. *Tourism Management, 80*, 104125. https://doi.org/10.1016/J.TOURMAN.2020.104125.

Rogers, E. (1962). *Diffusion of innovations*. Free Press of Glencoe.

Salinas, J. A., Guiata, J. M., & Martín, J. M. (2022). An analysis of the competitiveness of the tourism industry in a context of economic recovery following the COVID19 pandemic. *Technological Forecasting and Social Change*, 174, 121301.

Sigala, M. (2018). New technologies in tourism: From multi-disciplinary to anti-disciplinary advances and trajectories. *Tourism Management Perspectives*, *25*, 151–155. https://doi.org/10.1016/J.TMP.2017.12.003.

SITA. (2017). *Flightchain White Paper*. https://Blockchain-x.eu/wp-content/uploads/2018/02/flightchain-whitepaper.pdf.

SITA. (2021). *MRO Blockchain*. https://www.sita.aero/mroBlockchain.

Sita & Shocard. (2016). *Travel identity of the future*. https://Blockchainlab.com/pdf/2016-05-00-idm-ShoCard-travel-identity-of-the-future.pdf.

Standing, C., Tang-Taye, J. P., & Boyer, M. (2014). The Impact of the Internet in Travel and Tourism: A Research Review 2001–2010. *Journal of Travel & Tourism Marketing*, *31*(1), 82–113. https://doi.org/10.1080/10548408.2014.861724.

Swan, M. (2015). *Blockchain: Blueprint for a New Economy*. Sebastopol CA: O'Reilly Media.

Szabo, N. (1994). *Smart Contracts Glossary*. https://web.archive.org/web/20160417212209/https://szabo.best.vwh.net/smart_contracts_glossary.html.

Travala. (2021). *Book hotels with AVA - Everything you need to know | Travala.com*. Travala.Com. https://www.travala.com/ava.

TrustaBit. (2022). *TrustaBit.io*. https://www.trustabit.io/.

Tui Group. (2017). *TUI Feature*. https://www.tuigroup.com/en-en/media/stories/special-themed-section/digitalisation-and-innovation/2017-06-22-tui-to-use-Blockchain-opportunities.

Tyan, I., Yagüe, M. I., & Guevara-Plaza, A. (2020). Blockchain Technology for Smart Tourism Destinations. *Sustainability 2020, Vol. 12, Page 9715*, *12*(22), 9715. https://doi.org/10.3390/SU12229715.

UNWTO. (2021a). *Digital Transformation | OMT*. https://www.unwto.org/es/digital-transformation.

UNWTO. (2021b). *Telefónica and the World Tourism Organization renew their commitment to promote sustainable, secure and competitive tourism development*. https://www.unwto.org/news/telefonica-and-the-world-tourism-organization-renew-their-commitment-to-promote-sustainable-secure-and-competitive-tourism-development.

UNWTO. (2022). *El turismo crece un 4% en 2021, muy por debajo aún de los niveles prepandémicos*. [*Tourism grows 4% in 2021, still well below pre-pandemic levels*]. https://www.unwto.org/es/news/el-turismo-crece-un-4-en-2021-muy-por-debajo-aun-de-los-niveles-prepandemicos.

Veloso, B., Leal, F., Malheiro, B., & Moreira, F. (2019). Distributed Trust & Reputation Models using Blockchain Technologies for Tourism Crowdsourcing Platforms. *Procedia Computer Science*, *160*, 457–460. https://doi.org/10.1016/J.PROCS.2019.11.065.

Wang, H., Zhang, M., Ying, H., & Zhao, X. (2021). The impact of Blockchain technology on consumer behavior: a multimethod study. *Journal of Management Analytics*, 8(3), 371–390. https://doi.org/10.1080/23270012.2021.1958264.

Werback, K., Brama, S., & Jeager, P. (2018). The Blockchain and the New Architecture of Trust (Information Polcy). *The Blockchain and the New Architecture of Trust (Information Polcy)*, *9780262038935*, 1–5. https://mitpress.mit.edu/books/Blockchain-and-new-architecture-trust.

Zupan Korže, S. (2019). How Smart Tourism Embrace Blockchains and Smart Contracts. *Mednarodno Inovativno Poslovanje = Journal of Innovative Business and Management*, *11*(2), 32–40. https://doi.org/10.32015/JIBM/2019-11-2-4.

Chapter 8

Social Attitude towards P2P Digital Tourism Platforms: Is the Long-Term Sustainability of Mass Tourism Threatened?

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Abstract

This chapter analyzes the factors that influence the social attitude towards tourism accommodation online platforms, a key issue that largely determines the long-term sustainability of mass tourism. After an extensive review of the bibliography and the theoretical foundations and based on a survey carried out with different stakeholders in the city of Granada (Spain), an empirical work is conducted in two phases. First, through a factorial analysis, the multiple economic and social impacts that influence individuals' attitudes about the activity of these platforms are synthesized. Secondly, an ordered logistic regression is estimated to evaluate the different economic and sociocultural factors that can influence these attitudes (age, place of residence, level of studies, profession, social group, relationship with tourist activity, etc.). The conclusions of our analysis underline the influence of certain economic factors as fundamental determinants of the positive attitude of these

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platforms, while certain sociocultural factors could have a negative impact on them. The stakeholder type appears crucial too.

Keywords: digitalization, social sustainability, mass tourism, tourist accommodation online platforms

Introduction

The tourism industry is currently one of the main economic engines in much of the world (Joshi, Poudyal & Larson, 2017). In fact, the remarkable growth of international tourist flows (Gómez-Vega & Picazo-Tadeo, 2019) has made this sector surpass in importance others that had traditionally been basic pillars in the development of many countries (Mendola & Volo, 2017). In developed economies, tourism complements other productive activities, and, in some regions, it has replaced declining activities as the main source of income (Martín, Salinas, Rodríguez, & Ostos, 2020). In the developing world, the tourism industry has frequently come to position itself as a key activity in development strategy (Joshi, Poudyal & Larson, 2017). The international importance of tourism is beyond doubt. This sector is directly or indirectly responsible for 1 in 10 jobs worldwide (UNWTO, 2020), as well as 10.3% of world GDP (WTTC, 2020). This ability to generate employment and wealth collides on numerous occasions with environmental and social sustainability (Guaita & Martín, 2019). Social sustainability has been compromised by decades of pro-growth policies and the spread of low-cost mass tourism (Russo & Quaglieri, 2014). This has increased pressure on the tourist areas of many cities (Martín, Ostos & Salinas, 2019). Added to that is the growing expansion in the number of tourist homes mediated through online platforms (P2P). These platforms have introduced large tourist flows in residential environments, increasing interference in residents' lives (Gravari-Barbas & Guinand, 2017). Their activity has caused alterations in coexistence and social cohesion in the neighborhoods (Gant, 2016). Guttentag (2015; 1193) defines these platforms as: "essentially an online platform through which ordinary people rent out their spaces as accommodation for tourists." The sum of these factors has led to an economically positive activity arousing feelings of rejection (Cheung & Li, 2019). The tourist saturation of certain destinations, known as overtourism, has evolved into the most recent phenomenon named tourismophobia (Coldwell, 2017; Martín, Rodríguez, Zermeño, Salinas, 2018).

The aforesaid rejection cannot be treated as a minor matter, there are numerous studies that have recognized the importance of having residents' support for tourism activity, as a condition to guarantee the success of tourism development (Dyer, Gursoy, Sharma & Carter, 2007). In this sense, the social sustainability of destinations is increasingly recognized and valued (Dempsey, Bramley, Power & Brown, 2011). Therefore, greater attention is paid to the way in which tourism interacts with the environments in which it develops (Guaita, Martín & Salinas, 2020). The activity of P2P platforms is considered as a disruptive innovation with a great power of transformation (Guttentag, 2019). Since the first online tourist accommodation intermediation companies began their activity in 2008, academic research on this phenomenon has not stopped growing (Suess, Woosnam, Mody, Dogru & Turk, 2020). Numerous lines of research have been launched around this activity. Recently, as part of this scientific production, the line of study focused on the analysis of the impacts -positive and negative- on residents has been consolidated (Jordan & Moore, 2018; Quattrone et al., 2016; Gunter & Önder, 2018; Gutiérrez et al., 2017). The works included in this line of research have described numerous impacts associated with these platforms, which will be taken as a reference in this research.

As a sub-line of work, the analyses focused on the perception of citizens about the impacts described are still very scarce (Gutiérrez et al., 2017; Richardson, 2015; Lyons & Wearing, 2015). Several authors have highlighted the importance of completing research on perception analyses (Mody et al., 2020; Yeager et al., 2020; Lyons & Wearing, 2015; Richardson, 2015; Gutierrez, et al., 2017), which will help to know how these activities interact with their environments, starting from the assessment of the residents themselves (Guttentag, 2015; Gallagher, 2017). This will support the planning and regulation processes, adapted to the needs of the groups involved (Stergiou & Farmaki, 2019; Cheng, 2016), a regulation that is currently poorly developed and fragmented within the same country (Guttentag, 2015; Oskam & Boswijk, 2016; Martín et al., 2019). This work is intended to cover the outstanding research gap, offering a complete analysis of the perception of impacts associated with this activity. The proposed analysis integrates, as an added value, the opinion of various stakeholders, supports the perception of a wide list of impacts highlighted in the academic literature, and sets as an objective to study the importance of economic and social impacts in the configuration of global opinion on platforms. Specifically, our analysis aims to answer the following questions: What types of impacts do condition citizens opinion about platforms to a greater extent? Is this attitude conditioned by the

perception of economic or social impacts? How does the type of stakeholder influence the attitude towards the platforms?

The study is based on a fieldwork carried out in the city of Granada (Spain) in April 2020, which consisted of conducting 600 online surveys of city residents. The city is selected for being one of the main tourist destinations in Spain. It has 15,000 traditional tourist accommodation beds (National Statistics Institute, 2020a), and it is estimated that tourist housing provides 3,750 more beds (Datahippo, 2020). The city, a benchmark in cultural tourism, annually receives more than 2 million tourists (National Statistics Institute, 2020a). In addition, being a medium-sized city, it is the Spanish city with the highest density of tourists per inhabitant. Estimations indicate that the number of visitors received annually compared to the local population offers a ratio of 11.7% while the national average is 7.4% (Exceltur 2020).

Our empirical analysis studies the influence of the perception of the economic and social impacts and of the stakeholder type in the configuration of the attitude towards the platforms. The analysis is carried out in two phases: first, to order and synthesize the extensive information derived from the survey, a factorial analysis is carried out which, in addition to systematizing this information, contributes to mitigating the correlation problem derived from the survey structure. Second, an ordered logistic regression analysis is performed to detect the main economic and social factors that determine respondents' attitudes. The conclusions of this analysis underline the importance of certain economic factors as fundamental determinants of a positive attitude towards these platforms, while certain sociocultural factors could reduce the positive attitude that citizens have of them. The stakeholder type is crucial too.

Perception of the Impacts Associated with P2P Platforms for Intermediation of Tourist Accommodation

Tourism activity generates complex interactions on the environments it takes place in (Puczkó & Rátz, 2000). These interactions are expressed in a particular way in the so-called tourism impacts, which can be negative or positive (Martín, 2019). Obviously, these impacts will be perceived in a very different way depending on the stakeholder on which they fall (Prayag, Hosany, Nunkoo & Alders, 2013), since each group has different interests (Woo, Uysal & Sirgy, 2018). The final balance of the impacts on a destination

will depend on several factors, among which the type of activities carried out by tourists, the volume of visitors, the strength of the local culture or the fragility of the environment stand out (Roberts & Hall, 2001). Equally important to guarantee the sustainable development of tourist activity is the institutional environment its development is based upon. In this sense, the regulation of the sector and the mechanisms defined to adapt this activity to the needs of the different stakeholders are decisive (Martin et al., 2019; Fang, Ye & Law, 2016). It is desirable that the stakeholders involved support the development of tourist activity (Cole, 2006), as part of the long-term sustainability of this activity depends on this support (Gursoy, Chi & Dyer, 2010). The academic literature has formulated various hypotheses that seek to explain the way in which citizens define their attitude towards tourism. Those that inspire this work will be exposed in the following section.

Parallel to the increase in the activity of P2P platforms, studies focused on analyzing the impacts associated with such activity have grown in number. As a preliminary step to the description of such impacts and to contextualize it, it is interesting to offer some representative figures of this intermediation system. Accommodation places intermediated through P2P platforms represented 7% of the global accommodation supply in 2018 (World Bank, 2018). This implies an offer of around 8 million beds. The leading company in this sector, Airbnb, offers accommodation in more than 100,000 cities, hosting an average of more than 2 million guests per night (Inside Airbnb, 2020). A study conducted by Mastercard estimates that the total value of transactions associated with P2P platforms in the tourism sector amounts to 139 billion dollars (Ayuntamiento de Madrid, 2019).

Below are the main impacts associated with P2P platforms in the tourism sector. However, this analysis is still incomplete, and studies are required to assess benefits and costs more completely (Cheng, 2016; and Guttentag, 2015). In recent years, the pressure on local communities has increased due to the growing flows of visitors to residential environments (Russo & Quaglieri, 2014). In extreme cases, residents may be forced to leave their residence in search of more suitable environments (Russo, 2002). The foregoing would be associated with gentrification processes, which alter the profile of the residents of the neighborhoods and that of the businesses located in the area (Gotham, 2005). This transformation process can be defined as follows: “a process of socio-spatial change in which neighborhoods are transformed according to the needs of affluent consumers, residents and visitors alike” (Cócola, 2015: 4). Thus, the excessive concentration of tourist accommodation in certain areas and the increase in rental prices can promote gentrification (Richards, 2016).

The gentrification processes associated with the increase in tourist accommodation are also known as "airbnbification" (Richards, 2016). The above responds to an extreme situation, although the effects can be much more moderate and subtle. Effects such as the displacement of long-term tenants, growth in rental prices and a shortage of rental housing have been described (Edelman & Geradin, 2015; Guttentag, 2015; Gurran & Phibbs, 2017; Wegmann & Jiao, 2017; Postma & Schmuecker 2017; Richards, Brown & Dilettuso, 2019; Lines, 2015). Several studies have indicated that even when these activities can supplement the income of residents in tourist areas, they can also degrade working conditions in cases where income depends exclusively on them (Lyons & Wearing, 2015; Schor & Fitzmaurice, 2015). Evidence of the impact of this accommodation modality on the salaries of employees in traditional accommodation establishments has also been reported (Suciu, 2016), as well as effects in the reduction of the occupation of these (Fang et., 2016). From the point of view of coexistence, academic research has highlighted the negative effect on the loss of social cohesion (Cócola, 2016; Gallagher, 2017), and other changes that generate clear discomfort for residents. Such would be the case of increased traffic, higher noise level in residential buildings, perception of insecurity and congestion of public space (Gallagher, 2017; Gurran & Phibbs, 2017; Martin et al., 2017; Suess, Woosnam & Erul, 2020). Users may suffer some negative consequences associated with greater insecurity in hosting or economic transactions (Sigala, 2017). Society may be harmed because of tax evasion associated with these activities, or due to the unfair competition suffered by the traditional accommodation sector (Lyons & Wearing, 2015; Oskam & Boswijk, 2016; Zevras et al., 2014; Choi, Jung, Ryu, Do Kim & Yoon, 2015). Some of the impacts described could be associated with a lack of planning/regulation, rather than with the intermediation activity of these platforms (Martin et al., 2019; Nieuwlanda & van Melik, 2020).

Likewise, positive effects associated with the activity of these platforms have been described, also being varied. From the point of view of visitors, benefits such as the possibility of enjoying a more authentic experience have been highlighted (Forno & Garibaldi, 2015; Sigala, 2017; OECD, 2016; Tussyadiah & Pesonen, 2018; Russo & Quaglieri, 2016) and with a higher level of interaction with the locals (Belarmino, Whalen, Kohl, & Bowen, 2017). This type of accommodation expands the options for tourists, at a moderate price, (Shaheen, Mallery, & Kingsley, 2012; Juul, 2015; Ioannides et al., 2018). Moreover, the possibility of reducing spending on accommodation can increase the number of tourist trips (Zervas, Prosepio &

Byers, 2014). Some benefits for host communities have also been described. Destinations undoubtedly increase their reception capacity, which is especially beneficial during peak times (Juul, 2015). In cases where the accommodations are distributed throughout the city, tourist spending can be distributed in a more dispersed way (Porges, 2013). Local entrepreneurs can benefit, since undertaking activities included in the collaborative economy is usually easier (Nadler, 2014). Even when some studies have warned about the potential negative impact on community cohesion, others have pointed out that collaborative economy activities can promote values such as honesty, equality, mutuality, empathy, openness, and an ethic of care (John, 2013). And in general, the feeling of belonging to a community can be increased (Martin et al., 2015).

Theoretical Approach

In the academic literature there are several explanatory theories of the way in which the citizen attitude towards tourism is configured. Initial theories have been criticized for being too descriptive and not analyzing the reasons for those valuations (Gursoy & Rutherford, 2004). The following contributions made up for this weakness, trying to describe the rationality that supported the way in which the citizen attitude is formed (Martín, 2019). The proposal of Fishbein and Ajzen (1975), the theory of social carrying capacity (Savarides, 2000), Doxey's Irridex (Holden, 2006), the theory of Social Representation (Andriotis and Vaughan, 2003), Butler's intercultural perception model (Colantonio & Porter, 2006) or the Reasoned Action theory (Dyer et al., 2007) stand out. However, the theory that has generated the most acceptance is the "Social Exchange Theory" (SET), proposed by Richard Emerson in 1976, and applied specifically to the tourism sector by Ap (1992).

According to SET, the attitude of residents is shaped individually from an evaluation of the costs associated with and the expected benefits of the tourist activity (Ap, 1992). Thus, when citizens perceive that the benefits associated with tourism activity are greater than the costs, they will support tourism development (Lee, 2013). That is, local communities allow the development of the tourist activity, assuming the negative impacts that will be derived, if in return they expect to receive compensation – job creation, increase of income or improvement of the standard of living. Some studies have nuanced this theory by incorporating other factors that can interfere in the evaluation process (Gursoy et al., 2010). However, the use of SET in isolation has aroused

some criticism, since it assigns the main role of the evaluation processes to economic factors (Woosnam, Norman, & Ying 2009). One of the proposals that expand the range of factors to be considered in evaluation processes is Weber's Theory of Formal and Substantive Rationality (WTFSR) (Boley and McGhee 2014; McGehee 2007). WTFSR presents the human decision-making process as an ongoing battle between intrinsic (substantive) motivations and extrinsic (formal) motivations (Kalberg 1980). On the one hand, the formal rationality incorporates motivations related to economic aspects and livelihoods; while the substantive rationality refers to motivations related to values, cultural norms or informal decision making (Yeager et al., 2020). The present study assumes the importance of both theories, SET and WTFSR, since it proposes an analysis of the influence of the perception of the economic and social impacts in the configuration of the attitude towards the platforms.

The academic literature on this evaluation -general and referring to specific impacts- is recently gaining prominence (Jordan & Moore, 2018), although still scarce (Yeager, Boley, Woosnam & Green, 2020). The published studies do not show clear conclusions, in the sense of a marked rejection or acceptance of P2P platforms (Jordan & Moore, 2018; Stergiou & Farmaki, 2019; Richards et al., 2019; Stienmetz et al., 2019). Numerous studies have described attitudes of rejection and feelings of tourism-phobia (Martin et al., 2019). But there are also several studies that suggest a tolerant and positive attitude (Nunkoo & So, 2016; Mody, Suess & Dogru, 2019; and Suess, Woosnam & Erul, 2020). Since the general evaluation is not conclusive, it is interesting to determine what factors condition a positive attitude. There are several studies that have advanced on this path, such as those proposed by Garau-Vadell, Gutiérrez-Taño, and Díaz-Armas (2018), Mody, Suess, and Dogru, (2018), or Yeager et al., (2020). These studies have highlighted the importance of the perceived economic benefits and costs, but also of factors such as the social and psychological empowerment from tourist development, the perception of the economic situation or the collaborative economy in general (Garau-Vadell et al., 2019). It has been argued that the perception of these platforms can be positive, if they do not disturb the lives of the neighbors. This is defined by Guttentag (2017: 106) as: "In effect, Airbnb has produced a sort of 'Not in my backyard' in which Airbnb is popular in theory, but many people do not want it near them." In this evaluation it is interesting to introduce the differentiated opinion of the stakeholders involved (McGehee & Andereck, 2004; Kim et al., 2013), as proposed in this work, since citizens relate to this phenomenon in different ways (Cohen & Munoz, 2016; Domínguez-Gómez & González-Gómez, 2017). Introducing different

profiles in the analysis -users, owners, neighbors, merchants, etc.- it will be possible to verify the effect of the economic and social conditions for each group (Guttentag, 2015; McGehee and Andereck, 2004; Suess, et al., 2020).

Methodological Issues

Field Work and Its Context

As stated in the introduction, the field work on which this study is based was carried out in the city of Granada, southern Spain. Granada is one of the main tourist destinations in the country, receiving more than 2 million visits annually, of which 50% are from foreigners (National Statistics Institute, 2020a). This volume of visits does not include users of dwellings brokered on P2P platforms, since official bodies do not include them in their statistics. Thus, the volume of tourists arriving is much higher. Some studies affirm that 55% of those who arrive in the city use accommodation contracted through online platformse (Exceltur, 2018). In this city, the main tourist points are concentrated in the historic center, where a large part of the accommodation places are also located. The pressure exerted on these environments, in addition to causing inconvenience to the neighbors, has led to the conversion of a large number of residential homes into tourist accommodation and a large part of the commercial offer is aimed at tourists (Romero & Leontidis, 2019). This is leading to an impoverishment of community life and a lack of organization of coexistence (Romero & Leontidis, 2019).

The data was collected from April 6 to April 19, 2020, through an online survey applied to residents of the city. The survey was distributed with the help of local associations, public entities, the University of Granada, and social networks. Finally, 600 citizens responded. In addition to collecting basic demographic data, respondents were asked to rank items grouped in a block of “impacts” in terms of perceived intensity, which were drawn from the academic literature. Finally, it was requested to indicate the global attitude (opinion) towards online platforms for intermediation of tourist accommodation. These questions were rated on a Likert-type scale.

Interviewees were specifically asked about the role (whether resident, owner, etc.) that had conditioned their responses. The assigned groups are as follows: residents in tourist neighborhoods, residents in non-tourist neighborhoods, owners of tourist flats, street shops and restaurant owners,

professionals whose income depends on tourism, local citizens who live in buildings with tourist flats and users of peer-to-peer accommodation platforms. The questionnaire was divided into several sections, from which we will use the following three. First, respondents were asked for personal data, such as age, education level, and place of residence. Citizens who had not lived for more than one year in the city of Granada were excluded. Then, respondents were asked to rank a list of 10 positive impacts associated with tourist accommodation platforms on their environment (see Table 1, Question 9), ensuring that the highest score is awarded to the one they consider most important - more clearly perceived. Finally, the respondent was asked to indicate the role (whether resident, owner, etc.) that had conditioned his or her answers. The potential fear of contagion of diseases carried by tourists has been added to these impacts, because of the COVID-19 pandemic. After removing observations from individuals who did not reply to some of the survey questions, there are 302 complete observations of city residents.

Results

Statistical and Econometric Estimations

As stated in the Introduction, the analysis is conducted in two steps. First, we apply factor analysis to respondents' answers to Question 9 (Table 1). The objective is to synthesize respondents' perceptions on P2P tourism platforms and to avoid the correlation problems resulting from the ranking structure of the answers. Secondly, an ordered logit regression is estimated. The Likert-type scale answers in Question 10 (Table 1) make an ordered logit regression the appropriate quantitative analysis to study the main determinants of respondents' opinions on P2P tourism platforms (Winship and Mare, 1984).

Before proceeding with the analysis, Table 2 shows an overview of the data collected by summarizing the descriptive statistics for the dependent variable *opinion* and for the independent variables (a more detailed summary of observations per answer type is Table A1 in the Appendix). The median respondent has a neutral *opinion* on rental platforms (with a slightly negative mean). In terms of the socio-economic characteristics of the respondents, the median respondent falls within the 36-55 age range, has university education, does not live in a tourist neighborhood, does not have tourist apartment in own building, and reports not having tourist-related income despite considers

she/he belongs to the group whose income depends largely on the tourist sector. Finally, the median respondent has not had a recent change of opinion, thinks that tourism will be rejected for fears associated with COVID-19, and would feel fear/rejection to tourists in own building. As mentioned, respondents' answers to Question 9 will be discussed in the next subsection.

Exploratory Factor Analysis to Question 9 Answers

Since each respondent was required to rank the 10 economic and sociocultural items or impacts of P2P tourism platforms on a 1-10 scale, those items scores are correlated (see Table A3 in the Appendix). This makes factor analysis a useful tool to synthesize the information in fewer factors, not correlated for the purposes of model estimation. In this case, we assume there is a latent independent variable, individual–perception of the effects/impacts of P2P tourism platforms in environment, with several dimensions measured/ synthetized by the factors. Though the Pearson Correlation Coefficients of the 10 items ranked by respondents (Table A2 in the Appendix) are not high, they are mostly significant as expected. To further test the suitability of factor analysis, we apply the Bartlett test of sphericity ($\chi^2_{45} = 11058.70, p = 0.000$) that significantly rejects that the 10 items in Question 9 are not correlated and, hence, supports factor analysis. So, we proceed to apply factor analysis in the Stata package[1]. Exploratory Factor Analysis (EFA) is applied to the whole sample, 302 observations, following the prescriptions in Henson and Roberts (2006) and Mooi, Sarstedt and Mooi-Reci (2018) on application and reporting of EFA.

Table 3 captures the factor loadings after varimax rotation (orthogonal factors, i.e., not correlated to each other) of the four extracted factors that account for the 66.60% of the total variance. The factor loadings are the weights and correlations between each variable (each item in Question 9) and the factor (the higher the load the more determinant in the factor's dimensionality; a negative value indicates an inverse impact on the factor)[2].

[1] Stata uses as default the correlations matrix and blends factor analysis and principal components analysis (Mooi, Sarstedt and Mooi-Reci, 2018: 274).

[2] We also compute uniqueness, i.e., the variance that is unique to the item, not shared with other items and not accounted by the factors; for factor analysis to be useful, uniqueness values should be below 0.50 (Mooi, Sarstedt and Mooi-Reci, 2018: 278), and the condition is met.

Table 1. Survey questions, variables and codification

Order	Question and variable in analysis	Answers, Variable Type and Codification
1	Do you live in Granada city?	Yes: completes the survey No: out of the survey
2	You live in a tourist neighborhood: tourist_resident	Yes/No dummy variable (1/0)
3	Your income depends to some extent on the tourism sector: tourist_income	Yes/No dummy variable (1/0)
4	There is a tourist apartment in your building: tourist_inbuilding	Yes/No dummy variable (1/0)
5	Do you own a tourist apartment? owner	Yes/No dummy variable (1/0)
6	Do you work or own a shop at street level in a tourist area? businessman	Yes/No dummy variable (1/0)
7	Select your age range: age	Ordinal variable 18–35 years old: 1 36-55 years old: 2 56-65 years old: 3 >65 years old: 4
8	Select your level of studies completed: education	Ordinal variable Non finished education: 0 Primary education: 1 Secondary education: 2 University education: 3
9	Regarding online platforms for the rental of tourist accommodation such as Airbnb and the effects that their activity generates in their environment: order the following impacts according to which you perceive the most positive. Give a 10 to the most positive and a 1 to the least positive:	It encourages the conservation of buildings. (item 1) Enhancement of urban or historical areas. (item 2) The value of properties increases. (item 3) It improves the image of the city. (item 4) It improves cultural interaction. (item 5) Improvement of the leisure offer in the area. (item 6) They generate opportunities for local entrepreneurs. (item 7) They generate employment associated with tourism. (item 8) They generate wealth and economic activity. (item 9) Increase in tax collection. (item 10)

Order	Question and variable in analysis	Answers, Variable Type and Codification
10	Opinion on the effect of tourist housing rental platforms have on your environment: opinion	Ordinal Dependent Variable They affect in a very negative way: -2 They affect in a negative way: -1 The effect is neutral: 0 They affect in a positive way: 1 They affect in a very positive way: 2
11	Has your opinion changed in the last 30 days? change	Categorical variable Yes, for the better: 2 No: 1 Yes, for the worse: 0
12	Do you think that tourism will be rejected for fear of health infections associated with COVID-19 in your city? covid_rejection	Ordinal variable Yes, intensively: 2 Yes, moderately: 1 No: 0 I could not pin it down:"-"
13	Would you feel rejection/fear to the flow of tourists in homes located in your building if it occurred? inbuilding_rejection	Ordinal variable Yes, intensely: 2 Si, moderately: 1 No: 0 I could not pin it down: "-"
14	If you can be included in more than one of the groups described below, from what perspective do you think you have answered the survey? Check an option: group	Categorical variable Resident in tourist neighborhood: 1 In your building there is a tourist rental housing: 2 My income depends largely on the tourist sector: 3 Owner of a tourist home: 4 Work or own a shop at street level in a tourist area: 5 User:6 Other: "-"

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Median
opinion	302	-0.010	1.174	Very negative	Very positive	Neutral
tourist_resident	302	0.434	0.496	0	1	0
tourist_inbuilding	302	0.245	0.431	0	1	0
tourist_income	302	0.364	0.482	0	1	0
owner	302	0.132	0.340	0	1	0
businessman	302	0.179	0.384	0	1	0
age	302	1.805	0.818	18-36	>65	36-55
education	302	2.656	0.510	None	University	University
change	302	-0.023	0.394	Yes, for the worse	Yes, for the better	No
covid_rejection	276	1.221	0.717	0	2	1
inbuilding_rejection	273	0.696	0.664	0	2	1
group	252	2.734	1.616	1	6	3

Table 3. Rotated factor loadings and unique variances

Variable	Factor 1	Factor 2	Factor 3	Factor 4
Item_1	-0.739	-0.134	-0.217	0.170
Item_2	-0.621	-0.353	-0.083	0.404
Item_3	-0.066	0.051	-0.857	-0.086
Item_4	0.096	-0.699	0.167	0.025
Item_5	0.599	-0.361	0.259	0.263
Item_6	0.745	-0.174	-0.196	0.053
Item_7	0.168	0.628	0.043	0.451
Item_8	0.057	0.391	0.665	-0.023
Item_9	-0.046	0.732	0.346	-0.022
Item_10	0.077	-0.044	0.008	-0.900

Next, we assign each item to the factor with the highest absolute loading, considering that when few factors are extracted loadings should be at least 0.50, and name each factor by the label that best characterizes the combined meaning of all the items associated with it (Mooi, Sarstedt and Mooi-Reci, 2018: 282)[3]. Hence, the highest positive loading for Factor1 is item_6 (improvement of leisure offer in the area), followed by item_5 (it improves cultural interaction); and the highest negative loadings are item_1 (it encourages the conservation of buildings) and Iitem_2 (enhancement of urban or historical areas). Thus, we label Factor1 as the "positive sociocultural perceptions" of P2P tourism platforms. Factor2 is mainly positively determined by Item_9 (they generate wealth and economic activity), and Item_7 (they generate opportunities for local entrepreneurs); and negatively impacted by Item_4 (it improves the image of the city). Then, Factor2 is labelled as the "positive economic perceptions" of P2P tourism platforms. Following the same criteria, Factor3 is named "mixed economic perceptions"; and Factor4, "negative increase in tax collection."

Model of Individual Opinion: Estimation Results

Our dependent variable, *opinion* (question 10), as a proxy of individual's opinion on the effects that P2P tourism platforms have on his/her environment, is an ordinal variable ranging from very negative to negative, neutral, positive,

[3] That is, we go row by row in Table 5 assigning items to factors. Moreover, when few factors are extracted, loadings should be at least 0.50 (Mooi, Sarstedt and Mooi-Reci, 2018: 282).

and very positive effect. The standard econometric model for this type of ordinal variables depends on both the number of categories of the variable (fewer than seven categories) and the distance between the distinct categories. When there are uncertainties regarding the distances between the distinct ordered categories (i.e., is there the same distance between "Neutral" and "They affect in a positive way", as between the latter and "They affect in a very positive way"), the ordinal logit model is the commonly used approach, since the multiple linear regression approach may lead to biased estimated coefficients due to the violation of its assumption of independent, identically distributed errors (Winship and Mare, 1984). Hence, we estimate the following ordered logit *model of individuals' opinion* on the effect that P2P tourism platforms have on his/her environment:

$$opinion_i = ordered\ logit(x_{ij})$$

where *i* denotes the individual (*i=1, 2…, N*) and *j* denotes his/her answer to question j ($j_{-10}=1, 2\ldots$) (any question other than number 10, which is the dependent variable).

Table 4 shows the estimation results of the various models depending on the independent variables included[4]. An exploratory correlation analysis between the independent variables reveals a very significant correlation between *tourist_income* and either one of *owner* or *businessman*. Moreover, the categorical variable *group* is correlated with *tourist_resident*, *tourist_income*, *owner* and *businessman*, as these variables are categories of *group* (the results of the corresponding tests are in the Appendix). Therefore, regression (1) only includes as independent variables the extracted factors of the answers to Question 9 to examine how these factors relate to the dependent variable *opinion*. Regression (2) adds all of the variables considered in Table 2 above, independently of their correlation. Regression (3) includes *group* instead of the variables *tourist_resident*, *tourist_income*, *tourist_inbuilding*, *owner* and *businessman*. And regression (4) excludes the *group* variable in favour of *tourist_resident*, *tourist_income*, *tourist_inbuilding*, *owner* and *businessman*. Moreover, the four models appear significant at 1% significant

[4] The inclusion of the variables *covid_rejection* and *inbuilding_rejection* reduces the initial 302 number observations to 251 observations, because those individuals who answered "cannot specify" to any of these two questions are dropped in the econometric analysis. Similarly happens with the variable *group* that further reduces the number of observations to 211.

level. The symmetry of the results of the distinct models, keeping in mind the correlations discussed above, seem to suggest the robustness of the results.

Table 4. Ologit regression coefficients of opinion model (standard errors)

VARIABLES	(1)	(2)	(3)	(4)
	opinion	opinion	opinion	opinion
factor1 (positive sociocultural percep.)	-0.247**	-0.0580	-0.0210	-0.0665
	(0.107)	(0.146)	(0.144)	(0.125)
factor2 (positive economic percep.)	0.457***	0.372**	0.354**	0.428***
	(0.108)	(0.150)	(0.147)	(0.132)
factor3 (mixed economic percep.)	-0.188*	-0.0778	-0.0186	-0.105
	(0.103)	(0.142)	(0.137)	(0.124)
factor4	0.193*	-0.0370	-0.0449	-0.0214
	(0.102)	(0.138)	(0.137)	(0.124)
tourist_resident		-0.228		-0.212
		(0.361)		(0.277)
tourist_income		-0.279		-0.325
		(0.380)		(0.308)
tourist_inbuilding		-0.497		-0.580*
		(0.342)		(0.297)
owner		1.550*		2.402***
		(0.824)		(0.480)
businessman		-0.237		0.843**
		(0.479)		(0.359)
2.age (36-55 years old)		0.0437	-0.105	0.0175
		(0.330)	(0.317)	(0.283)
3.age (56-65 years old)		0.817	0.763	1.074**
		(0.504)	(0.488)	(0.442)
4.age (>65 years old)		0.560	0.488	0.652
		(0.966)	(0.942)	(0.804)
1.education (Primary)		-0.0532	-0.703	2.257
		(1,032)	(910.9)	(1,218)
2.education (Secondary)		17.29	16.18	19.17
		(729.9)	(644.1)	(860.9)
3.education (University)		16.55	15.48	18.44
		(729.9)	(644.1)	(860.9)
1.change (None)		1.147**	1.043**	0.842**
		(0.490)	(0.479)	(0.426)
2.change (For better)		2.111***	1.838**	1.723**
		(0.744)	(0.724)	(0.674)
1.covid_rejection (Yes, moderately)		0.273	0.173	0.666*
		(0.414)	(0.408)	(0.361)
2.covid_rejection (Yes, intensively)		1.255***	1.132**	1.552***
		(0.450)	(0.439)	(0.400)

Table 4. (Continued)

VARIABLES	(1)	(2)	(3)	(4)
	opinion	opinion	opinion	opinion
1.inbuilding_rejection (Yes, moderately)		-0.591*	-0.659**	-0.423
		(0.328)	(0.323)	(0.281)
2.inbuilding_rejection (Yes, intensively)		-1.431***	-1.508***	-1.521***
		(0.470)	(0.461)	(0.436)
3.group (In your building, tourist rental housing)		-0.299	-0.347	
		(0.503)	(0.423)	
		(0.479)	(0.375)	
4.group (Owner of a tourist home)		1.317	2.670***	
		(0.963)	(0.582)	
5.group (Work or own a shop at street level in a tourist area)		1.980***	1.806***	
		(0.645)	(0.488)	
6.group (User)		0.755	0.953	
		(0.642)	(0.589)	
Observations	302	211	211	251
LR chi2 ()	28.43***	143.73***	136.18***	139.76***
Pseudo R2	0.0307	0.2170	0.2056	0.1793

*** 1% significance level.
** 5% significance level.
* 1% significance level.

The main results of the ordered logit regressions can be summarized as follows[5]. Keeping everything else constant, the probability of having a very good opinion on P2P tourism platforms, with respect to the conjunction of the remaining alternatives of *opinion*, increases when the respondent's Factor2 (economic perceptions of tourist accommodation rental platforms) increases by one unit; the respondent owns a tourist apartment (owner), is a businessman in a tourist area and belongs to the 56-65 age range; moreover, the respondent either had not changed his opinion in the previous 30 days (to the survey date) or had changed his opinion for the better; finally, when the respondent thinks that tourism will be rejected for fears of health infections associated with COVID-19. On the contrary, and keeping everything else constant, the probability of having a very good opinion on P2P tourism platforms, with respect to the conjunction of the remaining alternatives of *opinion*, decreases when the respondent's Factor1 (positive sociocultural perceptions) increases by one unit; the respondent has tourist rental housing in own building and would reject tourist rental housing in own building.

[5] On the interpretation of the ordered logit regression, see, for instance: https://stats.idre.ucla.edu/stata/output/ordered-logistic-regression/.

Conclusion and Final Considerations

Looking at the recent past, P2P platforms have contributed very significantly to the increase in national and international tourism flows, which has favored economic growth in many regions and cities around the world. However, the massification of tourism produces in certain places -generally the most saturated- quite a lot of social rejection, from which P2P platforms do not escape, as they are considered by citizens to be a fundamental instrument of tourist massification. The specialized literature has theorized about numerous factors that positively or negatively affect the social perception of these platforms. Social exchange theory and Weber's theory of formal and substantive rationality support the empirical work developed in this chapter.

With a field study that explores the factors that affect the attitude or opinion that a group of stakeholders from the city of Granada (Spain) have about P2P platforms, through factorial analysis and an ordered logistic regression, this work reveals that economic factors most affect the positive opinion of P2P platforms, while social or cultural factors can reduce the positive view that citizens have of them. As seems logical, the more or less positive attitude that rental platforms have depends, to a large extent, on the position that each one occupies in the universe of stakeholders that, in one way or another, are influenced by this type of tourism. In particular, the probability of having a very good opinion of this type of tourist platform increases when the interviewee owns a tourist apartment (owner), is a businessman in a tourist area and belongs to the 56-65 age range; and it decreases when interviewees have tourist rental housing in their own building and would reject tourist rental housing in their own building.

The results obtained may be relevant when designing regulations or policies aimed at tourism planning, especially if it is about designing actions that pursue social acceptance of the P2P platforms. When ordering this sector, the balance between the economic benefits that can be expected from the platforms, particularly among those stakeholders whose income depends largely on the influx of tourists, and the social and cultural costs that the rest of society may be bearing, should be very present in the mind of the regulator. Even more so if there is real concern for the long-term economic and social sustainability of a sector that has contributed in a notable way to universalizing tourism and improve the living conditions of many citizens.

Appendix

Table A1. Survey variables and observations

Variables	Values	N
tourist_resident	0	171
	1	131
tourist_income	0	192
	1	110
tourist_inbuilding	0	228
	1	74
owner	0	262
	1	40
businessman	0	248
	1	54
age	1 =[18,35]	124
	2= [36,55]	125
	3 = [56,65]	41
	4 = [66, +]	12
education	0 = sin estudios	1
	1 = primarios	2
	2 = secundarios	97
	3 = universitarios	202
opinion_change	1 = Sí, a mejor	20
	0 = No	255
	-1 = Sí, a peor	27
covid_rejection	2 = Sí, intensa	108
	1 = Sí, moderada	121
	0 = No	47
	"-" = No puede precisar	26
inbuilding_rejection	2 = Sí, intensa	31
	1 = Sí, moderada	128
	0 = No	114
	"-" = No puede precisar	29
group	- = otro	50
	1 = residente en barrio turístico	86
	2 = edificio con vivienda turística	35
	3 = ingresos del sector turístico	53
	4 = propietario vivienda turística	31
	5 = trabaja o posee comercio zona turística	32
	6 = usuario de vivienda turística	15

Exploratory Factor Analysis

Table A2 shows the Pearson Correlation Coefficients of the 10 items ranked by respondents in question 9 (significance levels below in parentheses). One

can see that though correlation coefficients are not high, they are mostly significant, as it should be expected from the ranking scheme required when answering to Question 9.

Table A2. Pearson correlation coefficients of 10 items ranked in Question 9 (significance levels)

	item 1	item 2	item 3	item 4	item 5	item 6	item 7	item 8	item 9	item 10
item 1	1.000									
item 2	0.370	1.000								
	(0.000)									
item 3	0.076	0.016	1.000							
	(0.189)	(0.789)								
item 4	-0.128	0.023	-0.076	1.000						
	(0.026)	(0.688)	(0.189)							
item 5	-0.328	-0.190	-0.244	0.111	1.000					
	(0.000)	(0.001)	(0.000)	(0.054)						
item 6	-0.353	-0.275	-0.089	0.030	0.287	1.000				
	(0.000)	(0.000)	(0.124)	(0.599)	(0.000)					
item 7	-0.179	-0.182	-0.131	-0.228	-0.109	-0.083	1.000			
	(0.002)	(0.002)	(0.023)	(0.000)	(0.059)	(0.151)				
item 8	-0.313	-0.338	-0.352	-0.171	-0.041	-0.169	0.113	1.000		
	(0.000)	(0.000)	(0.000)	(0.003)	(0.478)	(0.003)	(0.049)			
item 9	-0.169	-0.254	-0.270	-0.418	-0.186	-0.183	0.251	0.322	1.000	
	(0.003)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)		
item 10	-0.207	-0.312	-0.082	-0.066	-0.130	0.004	-0.261	0.035	-0.062	1.000
	(0.000)	(0.000)	(0.158)	(0.257)	(0.024)	(0.947)	(0.000)	(0.542)	(0.283)	

Table A3. Factor analysis (unrotated)

Factors	Eigenvalues	Proportion	Cumulative
Factor1	2.258	0.226	0.226
Factor2	1.907	0.191	0.416
Factor3	1.291	0.129	0.546
Factor4	1.141	0.114	0.660
Factor5	0.905	0.091	0.750
Factor6	0.727	0.073	0.823
Factor7	0.620	0.062	0.885
Factor8	0.586	0.059	0.944
Factor9	0.564	0.056	1.000
Factor10	0.000	0.000	1.000

We also apply the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. The KMO measure (KMO = 0.044) does not recommend factor analysis. However, as practical experience does not seem to recommend KMO

with a small number of variables as in our case study (De la Fuente Fernández, 2011). Table A3 shows the initial factors extraction. The eigenvalue is the total variance accounted by each factor. The Kaiser criterion suggests keeping those factors with eigenvalue equal or higher than one (Mooi, Sarstedt and Mooi-Reci, 2018, p. 278), which in our case implies keeping the first four factors. Proportion indicates the total weight of each factor on the total variance. The Cumulative column shows that the first four factors account for the 66.60% of the total variance.

Model Estimation

Correlation among independent variables *group*, *tourist_income*, *owner* and *businessman*. As these variables are categorical (*group*) or dummy, a Kruskal Wallis[6] no-parametric test of correlation is performed for each case. Tests results suggest significant correlation among them and justify the estimation of models (3) and (4) in Table 4.

Table A4. Kruskall Wallis non-parametric test of correlation

Kruskal Wallis test (p-value)	owner	businessman	group
tourist_income	K = 35.97 (p = 0.000)	K = 20.25 (p = 0.000)	K = 33.32 p = 0.000
group	K = 17.63 (p = 0.000)	K = 26.81 (p = 0.000)	

References

Ayuntamiento de Madrid. (2019). Análisis del Impacto de las Viviendas de Uso Turístico en el Distrito Centro [*Analysis of the Impact of Housing for Tourist Use in the Central District*]. Ayuntamiento de Madrid, Madrid.

Andriotis, K., & Vaughan, R. D. (2003): "Urban residents' attitudes toward tourism development: the case of Crete," *Journal of Travel Research*, nº 42 (2), 172-185.

Ap, J. (1992). "Residents' perceptions on tourism impacts," *Annals of Tourism Research*, nº 19 (4), 665-690.

[6] For example: Siegel, S. and Castellan, Jr. N.J. (1988). *Nonparametric Statistics for the Behavioral Sciences* (second edition). New York: McGraw-Hill.

Banco Mundial. (2018). *Tourism and the Sharing Economy*. Retrieved from: http://documents1.worldbank.org/curated/en/161471537537641836/pdf/130054-REVISED-Tourism-and-the-Sharing-Economy-PDF.pdf (Accessed 10th January 2020).

Belarmino, A., Whalen, E., Koh, Y., Bowen, J. T. (2017). Comparing guests' key attributes of peer-to-peer accommodation and hotels: Mixed-methods approach. *Current Issues in Tourism*, 22, (1), 1-7.

Boley, B. B., and N. McGehee. 2014. "Measuring Empowerment: Developing and Validating the Resident Empowerment through Tourism Scale (RETS)." *Tourism Management* 45, 85–94.

Cheng, M. (2016). Sharing economy: A review and agenda for future research. *International Journal of Hospitality Management*, 57, 60–70. https://doi.org/10.1016/j.ijhm.2016.06.003.

Cheung, K. S., & Li, L.-H. (2019). Understanding visitor–resident relations in overtourism: developing resilience for sustainable tourism. *Journal of Sustainable Tourism*, 27(8), 1197–1216. https://doi.org/10.1080/09669582.2019.1606815

Choi, K. H., Jung, J. H., Ryu, S. Y., Do Kim, S., Yoon, S. M. (2015). The relationship between Airbnb and the hotel Revenue: In the case of Korea. *Indian Journal of Science and Technology*, 8, (26), 1-8.

Cócola, A. (2016). Holiday rentals: The new gentrification battlefront. *Sociological Research Online*, 21(3), 1–9.

Cócola, A. (2015). Tourism and commercial gentrification. *RC21 International Conference on ''The ideal city: between myth and reality. Representations, policies, Contradictions and Challenges for Tomorrow's Urban Life*'', Urbino, 27-29 August, available at: www.rc21.org/en/wp-content/uploads/2014/12/E4-C%C3%B3cola-Gant .pdf (accessed 8 May 2017).

Cohen, B., Munoz, P. (2016). Sharing cities and sustainable consumption and production: towards an integrated framework. *Journal of cleaner production*, 134, 87-97.

Colantonio, A., & Potter, R. B. (2006): *Urban tourism and development in the socialist state: Havana during the 'special period'*. La Habana: Ashgate Publishing.

Coldwell, W. (2017). *First Venice and Barcelona: now anti-tourism marches spread across Europe*. The Guardian. Retrieved from https://www.theguardian.com/travel/2017/aug/10/anti-tourism-marches-spread-acrosseurope-venice-barcelona (Accessed 10th August 2017).

Cole, S. 2006. "Information and Empowerment: The Keys to Achieving Sustainable Tourism." *Journal of Sustainable Tourism* 14 (6), 629–44.

Datahippo (2020). https://datahippo.org/es/ (Accessed 10th January 2020).

De la Fuente Fernández, S. (2011). Análisis Factorial [*Factorial Analysis*]. https://www.fuenterrebollo.com/Economicas/ECONOMETRIA/MULTIVARIANTE/FACTORIAL/analisis-factorial.pdf accessed 01/09/2021.

Dempsey, N., Bramley, G., Power, S., Brown, C. (2011). The social dimension of sustainable development: Defining urban social sustainability. *Sustainable Development*, 19 (5), 289-300.

Domínguez-Gómez, J. A., González-Gómez, T. (2017). Analysing stakeholders' perceptions of golf-course-based tourism: A proposal for developing sustainable tourism projects. *Tourism Management*, 63, 135-143.

Dyer, P., Gursoy, D., Sharma, B., Carter, J. (2007). Structural modelling of resident perceptions of tourism and associated development on the Sunshine Coast, Australia. *Tourism Management*, 28(2), 409-422.

Edelman, B. G., Geradin, D. (2016). Efficiencies and regulatory shortcuts: How should we regulate companies like Airbnb and Uber? *Stanford Technology Law Review*, 19, (2), 293–328.

Exceltur (2018). https://www.exceltur.org/sala-de-prensa/ (Accessed 10th January 2020).

Exceltur. (2020). *Informe Perspectivas Turísticas* [*Tourism Perspectives Report*]. https://www.exceltur.org/perspectivas-turisticas/#.

Fang, B., Ye, Q., Law, R. (2016). Effect of sharing economy on tourism industry employment. *Annals of Tourism Res*earch 57, 234–278.

Fishbein, M., & Ajzen, I. (1975): *Belief, attitude, intention, and behavior*. Reading: Addison-Wesley.

Forno, F., Garibaldi, R. (2015). Sharing Economy in Travel and Tourism: the Case of Home-Swapping in Italy. *Journal of Quality Assurance in Hospitality & Tourism* 16, (2), 202–220.

Gallagher, L. (2017). *The Airbnb story: How three ordinary guys disrupted an industry, made billions ... and created plenty of controversy*. Houghton Mifflin Harcourt: Boston, U.S.A.

Gant, A. C. (2016). Holiday Rentals: The New Gentrification Battlefront. *Sociological Research Online*, 21(3), 112–120. https://doi.org/10.5153/sro.4071.

Garau-Vadell, J. B., Gutierrez-Tan~o, D., & Dıaz-Armas, R. (2019). Residents ' support for P2P accommodation in mass tourism destinations. *Journal of Travel Research*, 58(4), 549–565. https://doi.org/10.1177/0047287518767067.

Gómez-Vega, M., Picazo-Tadeo, A. (2019). Ranking world tourist destinations with a composite indicator of competitiveness: To weigh or not to weigh? *Tourism Management*, 72, 281-291.

Gotham, K. (2005). Tourism gentrification: The case of New Orleans' Vieux carre (French quarter). *Urban Studies*, 42(7), 1099-1121.

Gravari-Barbas, M., Guinand, S. (2017). *Tourism and Gentrification in Contemporary Metropolises International Perspectives*. Routledge: London, U.K.

Guaita, J. M., Martín, J. M., Salinas, J. A. (2020). Innovation in the Measurement of Tourism Competitiveness. In *Analyzing the Relationship Between Innovation, Value Creation, and Entrepreneurship* (Galindo-Martín, M.A., Mendez-Picazo, M.T., Castaño-Martínez, M.S. Eds.). IGI Global, pp. 268-288. doi: 10.4018/978-1-7998-1169-5.ch013.

Gunter, U., & Önder, I. (2018). Determinants of Airbnb demand in Vienna and their implications for the traditional accommodation industry. *Tourism Economics*, 24(3), 270–293. https://doi.org/10.1177/1354816617731196.

Gurran, N., Phibbs, P. (2017). When tourists move in: How should urban planners respond to Airbnb? *Journal of the American Planning Asso*ciation, 83(1), 80–92.

Gursoy, D., & Rutherford, D. G. (2004): "Host attitudes toward tourism: an improved structural model." *Annals of Tourism Research*, nº 31(3), 495-516.

Gursoy, D., Chi, C. G., Dyer, P. (2010). Locals' attitudes toward mass and alternative tourism: the case of Sunshine Coast, Australia. *Journal of Travel Research*, 49 (3), 381-394.

Gutierrez, J., García-Palomares, J. C., Romanillos, G., Salas-Olmedo, M. H. (2017). The eruption of Airbnb in tourist cities: Comparing spatial patterns of hotels and peer-to-peer accommodation in Barcelona. *Tourism Manage*ment, 62, 278-291.

Guttentag, D. (2015). Airbnb: disruptive innovation and the rise of an informal tourism accommodation sector. *Current Issues in Tourism*, 18 (12), 1192–1217.

Gutierrez, J., García-Palomares, J. C., Romanillos, G., Salas-Olmedo, M. H. (2017). The eruption of Airbnb in tourist cities: Comparing spatial patterns of hotels and peer-to-peer accommodation in Barcelona. *Tourism Management*, 62, 278-291.

Guttentag, D. (2019). Progress on Airbnb: a literature review. In *Journal of Hospitality and Tourism Technology* (Vol. 10, Issue 3, 233–263). Emerald Group Publishing Ltd. https://doi.org/10.1108/JHTT-08-2018-0075.

Henson, R. K., Capraro, R. M. and Capraro, M. M. (2004). Reporting practice and use of exploratory factor analysis in educational research journals: Errors and explanations. *Research in the Schools*, 11(2), 61-72.

Henson, R. K. and Roberts, J. K. (2006). Use of exploratory factor analysis in published research: Common errors and some comment on improved practice. *Educational and Psychological Measurement*, 66(3), 393-416. https://doi.org/10.1177/0- 01316440528 2485.

Holden, A. (2006): *Tourism studies and the social sciences*, New York, Routledge.

Ioannides, D., Röslmaier, M., Van der Zee, E. (2018). Airbnb as an instigator of 'tourism bubble' expansion in Utrecht's Lombok neighbourhood. *Tourism Geographies*, 21, (5), 822-840.

InsideAirbnb (2020). *Inside Airbnb Database.* Retrieved from: http://insideairbnb.com/get-the-data.html (Accessed 10th January 2020).

John, N.A. (2013). The social logics of sharing. *The Communication Review*, 16, (3), 113–131.

Jordan, E. J., & Moore, J. (2018). An in-depth exploration of residents' perceived impacts of transient vacation rent-als. *Journal of Travel & Tourism Marketing*, 35(1), 90–101. https://doi.org/10.1080/10548408.2017.1315844.

Joshi, O., Poudyal, Larson, L.C. (2017). The influence of sociopolitical, natural, and cultural factors on international tourism growth: A cross-country panel analysis. *Environment, Development and Sustainability*, 19 (3), 825-838.

Juul, M. (2015). *The Sharing Economy and Tourism. European Parliament.* http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568345/EPRS_BRI(2015)568345_EN.pdf.

Kalberg, S. 1980. "Max Weber's Types of Rationality: Cornerstones for the Analysis of Rationalization Processes in History." *American Journal of Sociology* 85 (5): 1145–79.

Kim, K., Uysal, M., & Sirgy, M. J. (2013). How does tourism in a community impact the quality of life of community residents? *Tourism Management*, 36, 527–540. https://doi.org/10.1016/j.tourman.2012.09.005.

Lee, T. H. (2013): "Influence analysis of community resident support for sustainable tourism development," *Tourism Management*, nº 34, 37-46.

Lines, G. E. (2015). Hej, not hej då: Regulating Airbnb in the new age of Arizona vacation rentals. *Arizona Law Review*, 57, (4), 1163–1182.

Lyons, K., Wearing, S. (2015). *The Sharing Economy Issues, Impacts, and Regulatory Responses in the Context of the NSW Visitor Economy*. NSW Business Chamber: Sydney, Australia.

Martín, J. M., Guaita, J. M. (2019). Entrepreneurs' attitudes toward seasonality in the tourism sector. *International Journal of Entrepreneurial Behavior & Research*, Vol. 26 No. 3, 432-448.

Martín, J. M., Ostos, M. S., Salinas, J. A. (2019). Why Regulation Is Needed in Emerging Markets in the Tourism Sector. *The American Journal of Economics and Sociology*, 78 (1), 225-254.

Martín, J. M., Salinas, J. A, Rodríguez, J. A., Jiménez, J. D. (2017). Assessment of the tourism's potential as a sustainable development instrument in terms of annual stability: Application to Spanish rural destinations in process of consolidation. *Sustainability*, 9, (10), 1692.

Martin, C. J., Upham, P., Budd, L. (2015). Commercial orientation in grassroots social innovation: insights from the sharing economy. *Ecological Economics*, 118, 240–251.

Martín, J. M., Salinas, J. A., Rodríguez, J. A., Ostos, M. S. (2020) Analysis of Tourism Seasonality as a Factor Limiting the Sustainable Development of Rural Areas. *Journal of Hospitality & Tourism Research*, 44 (1), 45-75.

Martín, J. M., Rodríguez, J. A., Zermeño, K. A., Salinas, J. A. (2018). Effects of vacation rental websites on the concentration of tourists—potential environmental impacts. An application to the Balearic Islands in Spain. *International Journal of Environmental Research and Public Health*, 15 (2), 347.

McGehee, N. G., Andereck, K. L. (2004). Factors Predicting Rural Residents' Support of Tourism. *Journal of Travel Research*, 43, 131-140.

McGehee, N. G. 2007. "An Agritourism Systems Model: A Weberian Perspective." *Journal of Sustainable Tourism* 15 (2), 111–124.

Mendola, D., Volo, S. (2017). Building composite indicators in tourism studies: Measurements and applications in tourism destination competitiveness. *Tourism Management*, 59, 541-553.

Mody, Makarand, Courtney Suess, and Tarik Dogru. 2018. "Not in My Backyard? Is the Anti-Airbnb Discourse Truly Warranted?" *Annals of Tourism Research* 74,198–203.

Mody, M., Suess, C., & Dogru, T. (2019). Not in my backyard? Is the anti-Airbnb discourse truly warranted? *Annals of Tourism Rese*arch, 74, 198–203. https://doi.org/10.1016/j.annals.2018.05.004.

Mody, M., Woosnam, K. M., Suess, C., Dogru, T. (2020). Hapless victims or empowered citizens? Understanding residents' attitudes towards Airbnb using Weber's Theory of Rationality and Foucauldian concepts. *Journal of Sustainable Tourism*, doi: 10.1080/09669582.2020.1834567.

Mooi, E., Sarstedt, M. and Mooi-Reci, I. (2018). "Principal Component and Factor Analysis," Springer Texts in Business and Economics, in: *Market Research*, chapter 8, 265-311, Springer.

Nadler, S. S. N. (2014). *The Sharing Economy: What Is It and Where Is It Going?* Institute of Technology: Massachusetts, U.S.A.

National Statistics Institute. (2020a). *Encuesta Ocupación Hotelera* [*Hotel Occupancy Survey*], 2019. https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736177015&menu=resultados&secc=1254736195376&idp=1254735576863#!tabs-1254736195431.

National Statistics Institute. (2020b). INEbase/*Demografía y población /Padrón*. Población por municipios /Cifras oficiales de población de los municipios españoles: Revisión del Padrón Municipal/Resultados [INEbase/*Demography and population/Register*. Population by municipalities/Official population figures for Spanish municipalities: Revision of the Municipal Register/Results]. https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736177011&menu=resultados&idp=1254734710990.

Nieuwland, S., van Melik, R. (2020). Regulating Airbnb: how cities deal with perceived negative externalities of short-term rentals. *Current Issues in Tourism*, 23, (7), 811-825.

Nunkoo, R., & So, K. K. F. (2016). Residents' support for tourism: Testing alternative structural models. *Journal of Travel Research*, 55(7), 847–861. https://doi.org/10.1177/0047287515592972.

OECD. (2016). *Policies for the Tourism Sharing Economy OECD Tourism Trends and Policies*. OECD Publishing: Paris, France.

Oskam, J., Boswijk, A. (2016). Airbnb: The future of networked hospitality businesses. *Journal of Tourism Futures*, 2, (1), 22–42.

Porges, S. (2013). The Airbnb effect: Bringing life to quiet neighborhoods. *Forbes.* Retrieved from http://www.forbes.com/sites/sethporges/2013/01/23/the-airbnb-effect-bringing- life-to-quiet-neighborhoods/.

Postma, A., Schmuecker, D. (2017). Understanding and overcoming negative impacts of tourism in city destinations: conceptual model and strategic framework. *Journal of Tourism Futures*, 3 (2), 144-56.

Prayag, G., Hosany, S., Nunkoo, R., Alders, T. (2013). London residents' support for the 2012 Olympic Games: the mediating effect of overall attitude. *Tourism Management*, 36, 629-640.

Puczkó, L., Rátz, T. (2000). Tourist and resident perceptions of the physical impacts of tourism at Lake Balaton, Hungary: Issues for sustainable tourism management. *Journal of Sustainable Tourism*, 8, 458–478.

Quattrone, G., Proserpio, D., Quercia, D., Capra, L., & Musolesi, M. (2016). Who Benefits from the "Sharing" Economy of Airbnb? 25th *International World Wide Web Conference*, WWW 2016, 1385–1393. http://arxiv.org/abs/1602.02238.

Richards, G. (2016). El turismo y la ciudad ¿Hacia nuevos modelos? [Tourism and the city. Towards new models?] *Revista Cidob d´afers internacionals*, 113, 71-87.

Richards, S., Brown, L., Dilettuso, A. (2019). The Airbnb phenomenon: the resident's perspective. *International Journal of Tourism Cities*, 6(1), 8-26.

Richardson, L. (2015). Performing the sharing economy. *Geoforum* 67, 121–129.

Roberts, L., Hall, D. (2001). *Rural tourism and recreation: Principles to practice*. CABI Publishing: Wallingford, UK.

Romero, E., Leontidis, C. (2020). *The Impact of Sharing Economy in Heritage Neighborhoods in Granada*. In I. de Luna, À. Fitó-Bertran, J. Lladós-Masllorens, & F. Liébana-Cabanillas.

Russo, A. P. (2002). The "vicious circle" of tourism development in heritage cities. *Annals of Tourism Research*, 29(1), 165-182.

Russo, A. P., Quaglieri, A. (2014). La Lógica Espacial del Intercambio de Casas: Una Aproximación a las Nuevas Geografías de lo Cotidiano en el Turismo Contemporáneo [The Spatial Logic of House Exchange: An Approach to the New Geographies of the Daily in Contemporary Tourism]. *Scripta Nova Revista Electrónica de Geografía y Ciencias Sociales*, 17, 483.

Russo, A. P., Quaglieri, A. (2016). The shifting spatial logic of tourism in networked hospitality. In A. P. Russo, & G. Richards (Eds.), *Reinventing the local in tourism: Producing, consuming and negotiating place* (pp. 15–34). Channel View Publications: New York, U.S.A.

Saveriades, S. (2000): "Establishing the social tourism carrying capacity for the tourist resorts of the east coast of the Republic of Cyprus," *Tourism Management*, nº 21(2), 147–156.

Schor, J. B., Fitzmaurice, C. (2015). Collaborating and Connecting: the Emergence of the Sharing Economy. In *Handbook of Research on Sustainable Consumption*. Eds. L. Reisch and J. Thogersen. Edward Elgar: Cheltenham, U.K.

Shaheen, S. A., Mallery, M. A., Kingsley, K. J. (2012). Personal vehicle sharing services in North America. *Research in Transportation Business & Management*, 3, 71-81.

Sigala, M. (2017). Collaborative Commerce in Tourism: Implications for Research and Industry. *Current Issues of Tourism* 20, (4), 346-355.

Stergiou, D. P., & Farmaki, A. (2019). Resident perceptions of the impacts of P2P accommodation: Implications for neighbourhoods. *International Journal of Hospitality Management*, https://doi.org/10.1016/j.ijhm.2019.102411.

Stienmetz, J. L., Liu, A., & Tussyadiah, I. P. (2019). *Information and communication technologies in tourism* 2012. Springer. https://doi.org/10.1007/978-3-7091-1142-0.

Suciu, A. M. (2016). *The impact of Airbnb on local labour markets in the hotel industry in Germany.* Retrieved from https://ssrn.com/abstract = 2874861.

Suess, C., Woosnam, K., Mody, M., Dogru, T., Sirakaya Turk, E. (2020). Understanding how residents' emotional solidarity with airbnb visitors influences perceptions of their impact on a community: The moderating role of prior experience staying at an Airbnb. *Journal of Travel Research*, https://doi.org/10.1177/0047287520921234.

Tussyadiah, I. P., Pesonen, J. (2018). Drivers and barriers of peer-to-peer accommodation stay: An exploratory study with American and Finnish travellers. *Current Issues in Tourism*, 21, (6), 703–720.

UNWTO (2020). UNWTO *World Tourism Barometer*, 18 (2). Madrid, Spain: UNWTO.

Wegmann, J. Jiao, J. (2017). Taming Airbnb: toward guiding principles for local regulation of urban vacation rentals based on empirical results from five US cities. *Land Use Policy*, 69, 494-501.

Winship, C. and Mare, RD. (1984). Regression Models with Ordinal Variables. *American Sociological Review*, 49, 512-525.

Woo, E., Uysal, M, Sirgy, M. J. (2018). Tourism impact and stakeholders' quality of life. *Journal of Hospitality & Tourism Research*, 42 (2), 260–286.

Woosnam, K. M., W. C. Norman, and T. Ying. 2009. "Exploring the Theoretical Framework of Emotional Solidarity between Residents and Tourists." *Journal of Travel Research* 48 (2), 245–58.

WTTC. (2020). *Travel & Tourism's direct, indirect and induced impact*. Retrieved from: https://wttc.org/Research/Economic-Impact. Accessed on 1st December 2020.

Yeager, E. P., Boley, B. B., Woosnam, K. M., & Green, G. T. (2020). Modeling residents' attitudes toward short-term vacation rentals. *Journal of Travel Research*, 59(6), 955–974. https://doi.org/10.1177/0047287519870255.

Zervas, G., Proserpio, D., Byers, J. (2014). *The rise of the sharing economy: Estimating the impact of Airbnb on the hotel industry*. Boston U. School of Management Research Paper, 2013-16.

Chapter 9

The Challenges of Digitalization in Public Administration. Case Study: Customs as an Example of Digital Transformation with the Aim of Facilitating Trade

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Abstract

Digitalization and Digital Transformation as tools to facilitate international trade without ignoring the other great principle on which it is based, namely security and control at the borders, and how they dictate the future evolution of international, European and, within its framework, Spanish Customs.

This objective, when it comes to combining both areas, follows the international trade directives, in which the latest events of our time are embbeded, from the threat of terrorism, to the recent impact that the COVID-19 pandemic has had on society worldwide, and as it could not be otherwise.

Thus, the new initiatives in the field of digitalization and digital transformation marked by these circumstances, directly affect international trade, the supply chain, and therefore, the agents involved

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in it, specialy administrations or public bodies such as Customs, where digitalization represents their present and their future.

Keywords: digitalization, digital transformation, trade facilitation, customs, European Union, supply chain

Introduction

The objective of this chapter is to highlight the paramount importance that digitalization at all levels has acquired in the current framework, accelerated rapidly in recent years.

In the development of our study, we will start by terminologically contrasting the concepts of digitalization and digital transformation to, on this base, offer a vision of the different lines of action at international, European and national levels, aligned with digital transformation from the perspective of public bodies in the logistics supply chain.

In order to do this, we will analyze the various initiatives, regulations and programs in the different organizations and areas, which will allow us to identify the place occupied by Spain in the international arena, the European Union and with respect to the rest of Member States.

Finally, we will focus on the Public Administration sector, and in particular Customs, as an example of digital transformation to progress from a rigid and slow administration to a more dynamic and efficient one based on the digitalization of its processes.

This entails the creation and transformation of the agents that form part of the logistics chain, which, by supporting this change towards the digitalization of their practices, will lead to greater agility. This will, in turn, result in greater competitiveness and readiness in the face of the changing environment in which we live, with the consequent reductions in time and costs in import or export operations, and without undermining the balance that must exist with traffic security.

Without further ado, we begin our journey to explore how digitalization has led to a revolutionary transformation where information is the basis of the entire system and in all areas of the current scenario in which we operate.

Digitalization versus Digital Transformation

We understand that it is necessary to contextualise our study by defining both digitalization and digital transformation, and by comparing and confronting both concepts and how they have evolved over the last few years.

This terminology/dichotomy is not limited to the present, but has been a subject of studies and debates at different times, and today applies to all spheres: Governments, health, security, Public Administration, education, logistics, banking, business, industry… in short, any imaginable field has been considered and is being affected by this transformation, which has accelerated vertiginously in recent years.

With this in mind, we will establish a brief conceptual framework on these two great concepts, which companies, Public Administrations and citizens have been forced to rapidly adopt in their day-to-day lives as a result of the COVID-19 pandemic.

We will start, as mentioned, by considering several definitions that will provide the basis to arrive at the current understanding of both concepts, the result of historical evolution, and their implications in companies and Public Administrations, which have not followed a homogeneous development in these fields either.

Therefore, we have to conduct a brief study on the terms "digitization" and "digitalization" as they are often used interchangeably; however, there is a clear distinction between the two. According to (Brennen & Kreiss, 2016), they are concepts that are closely associated but often used interchangeably across a wide range of publications. These authors focus mainly on how people interact with technologies, and how we are moving away from analog towards digital ones.

The Gartner IT Glossary (2022) focuses more on business models than on the interaction of people with technology, as seen in its definition of these concepts: "Digitization is the process of changing from analog to digital form, also known as digital enablement. Said another way, digitization takes an analog process and changes it to a digital form without any different-in-kind changes to the process itself", while "Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business."

On the other hand, and given the current existing constraints, we will focus on the concepts of Digitalization and Digital Transformation, which are the ones that have precipitated a large proliferation of literature. We will

therefore review the different definitions formulated by different authors, since there are multiple perceptions of digital transformation.

The Royal Spanish Academy defines Digitalization as 'the action and effect of digitalize' (Royal Spanish Academy, s.f.).

Young & Rogers, (2019, p 683) defines it as "a technology-driven process of change derived from ubiquitous data, connectivity and decision making."

For Spanish regulations, in Law 39/2015, of October 1, of the Common Administrative Procedure of Public Administrations in its article 27 point 3b) 2nd paragraph (BOE nº 236 Pág. 89363) digitalization is understood as "the technological process that allows the conversion of a document on paper or on another non-electronic support into an electronic file that contains the coded, faithful and complete image of the document".

Similarly, other authors define digital transformation as "transformation of key business operations and affects products and processes, as well as organizational structures and management concepts" (Matt et al., 2015 p 339).

Gavilán (2019, p 159) considers digital transformation "as a profound change undertaken by an organization to adapt to the challenges and take advantage of the opportunities generated by digital technology."

For the Organisation for Economic Co-operation and Development (OECD) (2020, P 15) the digital transformation of the economy and societies:

> "has changed expectations about governments, leading to pressure for greater openness and the creation of spaces and mechanisms where citizens and business can voice their needs. Failure to adjust to this new reality could bring risks for governments in terms of policy failures and the continued delivery of outdated and irrelevant services against a backdrop of emerging business models."

Furthermore, for Rozas J.P. (2019, p 2-4): "Digital transformation is a process of change where the first thing to do is look for the elements that will make our tasks easier (customer experience, operating processes, business models)".

Ismael et al. (2017), as cited in Verina, N and Titko, J (2019, p 721) defines digital transformation as: 'process through which companies converge multiple new digital technologies, enhanced with ubiquitous connectivity, with the intention of reaching superior performance and sustained competitive advantage, by transforming multiple business dimensions, including the business model, the customer experience (comprising digitally enabled products and services) and operations (comprising processes and decision-

making), and simultaneously impacting people (including skills talent and culture) and networks (including the entire value system)'

After analyzing several definitions and noting the differences that exist between both concepts and their implications in the different fileds (education, health, transport, logistics, public administrations...) in which the authors use them, we can better understand this dichotomy.

We can adopt, then, in order to clarify our subject, the following classification that, in turn, evolves in accordance with the historical moment that we are analyzing, until we reach the digital transformation that would correspond to the present. The classification could be the following:

1. Digitization: in this initial stage, it was limited only to converting analog information (paper) into digital format.
2. Digitalization: technology evolves and companies, Governments, Administrations carry out a "process" since, by having information in digital format, makes it accessible and readable by means of computers, machines or other technologies used to capture the necessary information and carry out the performance of another activity.
3. Digital transformation: it is a complex process which it is not only linked to a technological process in the company, but also requires a change or review of its business culture and for which all levels of the company must be involved from the start, from the management to the lower ranks. In addition, an important point to take into account is that the company, organization or public administration must invest in talent, that is, train and hire people to implement this transformation.

Having successfully reached this third step, the organization in question and in any fields, achieves the ultimate goal, a competitive advantage over the rest of the entities in its sector.

In conclusion, as we will indicate in a later chapter of our study, these terms are really necessary to understand the processes established by Public Administrations, and specifically Customs and their influence on the supply chain and international trade.

The Digitalization and Digital Transformation Strategy in Different International Organizations

In this section, we intend to offer an overview of the advances and digital strategies worldwide, all of them related, as it cannot be otherwise in the current moment of total interconnection in which we exist, and as applied in the field of International Trade.

As we can see throughout this study, there is a clear and growing commitment to the digitalization of processes and, above all, to digital transformation as a necessary and irreversible path in the time we live in.

As we have already mentioned, digitalization and digital transformation have delivered numerous benefits to companies, organizations, public administrations and citizens, and have led to the constant increase in certain digital activities in all imaginable sectors, such as the supply chain (export companies, importers, carriers, customs representatives, official inspection bodies, freight forwarders and Public Administrations, as in our case, Customs), driving the emergence of new business models that represent a great challenge for international trade.

However, we must not forget that development has been continuously increasing in recent years, and has exponentially accelerated in the last two in the context of the COVID-19 pandemic, as we can see by analyzing the volume and depth of studies, standards, agreements and recent programs of these organizations.

In the following sections of our study, we will focus on how advances have been made in all organizations and at all levels on issues of digitalization and digital transformation related to the supply chain and the public sector, especially Customs.

The Organisation for Economic Co-Operation and Development (OECD)

The Organisation for Economic Co-operation and Development (OECD) maintains that "Information and Communications Technology (ICT), advances in Artificial Intelligence (AI) and robotics are completely changing the way people think, communicate and live. Many now routinely use digital tools such as computers, smartphones and tablets, both at work and in everyday life" (OECD, 2019 p 59).

It also tells us that "Digitalization has tended to expand participation in Global Value Chains (GVCs) and has contributed to shaping the demand for skills by allowing the segmentation of tasks that facilitates their relocation. At the same time, the combination of greater global integration and digitalization is generating entrepreneurial opportunities" (OECD, 2019 p 65). For this reason, it is very important that governments and companies invest in talent, that is, training their workers in new skills required for these possible "new jobs" and in systems that anticipate these changes, to prevent possible layoffs and inequalities, since digitalization can sometimes lead to the automation of jobs and tasks that require basic skills and low qualifications.

The OECD offers us two tools to evaluate the digital transformation of the public sector through indices.

The first index is the Digital Government Index (DGI), which analyzes the transition from electronic government to digital government. "The DGI measures the maturity level of digital government strategies in OECD member and partner countries based on evidence gathered through the Survey on Digital Government 1.0" (Ubaldi, B. & T. Okubo, 2020, p 2).

That means that with the Digital Government Index (DGI) the OECD shows us a picture of each country, that is, where it is digitally.

- Analog Government: closed operations; analog procedures.
- E-Government: entails creating transparency and user-centric approaches. ICT-enabled procedures.
- Digital Government: open user-driven and data-driven approaches, processes and operational transformations.

This index is a tool used by said body to evaluate the implementation of the 2014 OECD Recommendation of the Council on Digital Government Strategies.

The structure of the index measures 6 dimensions (OECD, 2019) to be able to analyze at what point each government is and if that government is digitally mature; it analyzes both OECD countries and non-member countries.

Dimensions:

- The Government is digital by design, that is, digitalization is the basic, mandatory and fundamental element, which must be integrated into all its processes, both in its internal and external relations with

stakeholders, seeking to improve communication and simplify procedures.

- Data-based public sector, that is, understanding data as a strategic element for its use in the decision-making process.
- The Government acts as a platform, implements techniques to provide better service to citizens and like this measures the satisfaction of their needs.
- Governments must integrate open data efforts by default. In other words, they must make government data and policy-making processes available to citizens, always under the umbrella of existing legislation.
- The Government must be user-driven, prioritizing the needs of users in its policies, processes, …
- The Government must be proactive; anticipates the needs of citizens and implements them quickly.

We can agree that the results in the OECD organization are still modest, since few countries have advanced to the point of being considered mature digital governments.

The second index offered by the OECD (2020) is the Open, Useful and Reusable Data Index (OURdata Index), which is based on the Organization's analytical framework for open government data policies.

The pilot version of this index was in 2014, published in 2015 in the publication "Government at a Glance 2015" by the OECD.

This index evaluates the advances and challenges of thirty three governments at central/federal level, always related to the design and implementation of open data policies.

This second index is made up of three pillars Ubaldi, B., & Okubo, T. (2020).

A. *Data Availability* - Measures the extension and availability of promoting platforms, websites, ... by governments to establish open data, the participation of interested parties for the publication of said data and its implementation.
B. *Data Accessibility* - Measures the dissemination of the access policy by governments without data restrictions, since the OECD states that governments must focus on increasing the production and exchange of high-quality data, they should be proactive when entering data, and

this should be easily accessible and usable in other formats. The second component that this dimension measures is stakeholder engagement for data quality and integrity.

C. *Government Support for Data Reuse* - Analizes the support provided by governments for the reuse of data by external users (platforms, tools, training courses for officials on data management and open data), as well as the creation and implementation by said governments of OGD policies that focus on open data systems, data reuse and value creation, Lastly, it measures its impact monitoring.

The OECD offers diverse examples tested in several countries, one of which is Spain where "the Multisectoral Information Association, ASEDIE, publishes the Infomediary Sector Report annually in an effort to monitor and assess the effect of open data on economic activity in the country" (OECD, 2020, p 44).

It should be noted that as members of the EU, at the supranational level we are affected by the directives adopted by the EU; therefore, the 2019 EU Directive on open data and reuse of public sector information was essential at the time to support the advancement of open data efforts in EU member states and, thereby, to facilitate innovation and good governance.

Article 16 of the EU directive explicitly:

> "Open data as a concept is generally understood to denote data in an open format that can be freely used, re-used and shared by anyone for any purpose. Open data policies which encourage the wide availability and re-use of public sector information for private or commercial purposes, with minimal or no legal, technical or financial constraints, and which promote the circulation of information not only for economic operators but primarily for the public, can play an important role in promoting social engagement, and kick-start and promote the development of new services based on novel ways to combine and make use of such information. Member States are therefore encouraged to promote the creation of data based on the principle of 'open by design and by default', with regard to all documents falling within the scope of this Directive. In doing so they should ensure a consistent level of protection of public interest objectives, such as public security, including where sensitive critical infrastructure protection related information are concerned. They should also ensure the protection of personal data, including where information in an individual data set does not present a risk of identifying or singling out a natural person, but when that information is combined with

other available information, it could entail such a risk" (Parliament, E., 2019).

United Nations (UN)

The United Nations carry out surveys that focus on analyzing the monitoring of the global development of E-Government in its 193 member states. Its first publication dates from 2001, they are biennial and therefore the last survey to be analyzed will be that of 2020.

For this purpose, the United Nations uses the E-Government Development Index (EGDI) that measures the development of electronic Administration. The most important factors when contributing to the analysis of this index (EGDI) are "the progress in the provision of online transactional services, trends in the provision of mobile services and transformations at regional level in the development of E-Government" (United Nations. 2020, p.1). As can be seen when looking at the factors included, and as pointed out by the authors themselves, the links with the SDG objectives stand out, including those related to key priorities such as health, education, social services, worthy employement and universal justice.

Therefore, with this index we observe the ways in which technological innovations and the technology itself in digital matters are used by particular governments and how they impact the public sector; it not only analyzes whether said processes with the technologies are more efficient, but also how to ensure the participation, inclusion and responsibility of citizens. This is because the EGDI Index includes three other sub-indices:

- Online Services Index (OSI)
- Human Capital Index (HCI)
- Telecommunications Infrastructure Index (TII)

This area also includes a supplementary index, the E-participation Index (EPI), which measures the use of government telematic services in order to offer data to citizens and interact with them to collect their feedback with the aim of improving processes through online communication.

From this report we can infer a substantial and persistent improvement towards higher levels of development of E-Government worldwide, as a consecuence.

Another survey carried out by the UN that must also be taken into account is the Global Survey of the United Nations on Digital and Sustainable Trade 2021. It must be pointed out that these surveys are carried out by the five Regional Commissions of the United Nations (CEPAL, CEPA, UNECE, ESCAP and ESCWA). This will be the fourth survey evaluating progress in the implementation of trade facilitation measures by the 144 member states.

This initiative will serve to implement the WTO Trade Facilitation Agreement, as well as various regional and global initiatives on trade and paperless trade, which we will set out in more detail in the chapter on customs.

World Intellectual Property Organization (WIPO)

The World Intellectual Property Organization (WIPO) is the organization that edits and publishes the Global Innovation Index 2021, this being the 14th edition. This latest edition was prepared under the general direction of Daren Tang, Director General, in WIPO's IP and Innovation Ecosystems.

This index adopts a broad notion of innovation, originally elaborated in the Oslo Manual prepared by the European Union and the Organization for Economic Cooperation and Development (OECD).

This publication was created to chart the role that innovation plays in the economic and social development of economies for its subsequent dissemination. For this reason, they developed the Global Innovation Index (GII), which analyzes data related to innovation from 132 economies.

This index analyzes seven pillars (WIPO, 2021):

- Institutions
- Human capital and research
- Infrastructure
- Market sophistication
- Business sophistication
- Knowledge and technology outputs
- Creative outputs

Its latest edition gives Spain a score of 45.4 points and places it in 30th position out of the 132 countries analysed, 19th among European countries.

It should be noted that Spain excels especially in the area of Infrastructure, where it occupies the 13th position. This pillar is made up of several

components, two of which are specially relevant to our study: on the one hand, Information and Communication Technologies (ICT), in which it obtains 85.3 points (position 19th), that evaluates access, use of ICTs in delivering government services and electronic participation by citizens; and on the other hand, under General Infrastructue, the Logistics Performance Index (LPI) in which it obtains a score of 82.8 points (position 17th). This last index was created by the World Bank.

The World Bank

The World Bank has developed the Logistics Performance Index (LPI), as a tool to help the 160 countries to identify changes and opportunities in areas of trade and logistics. This index is used by the World Intellectual Property Organization as a component of its Global Innovation Index (GII).

The World Bank (as refered to in WIPO, 2021) notes that "the data used in the ranking come from a survey of logistics professionals who are asked questions about the foreign countries in which they operate".

According to the authors Arvis et al., (2018, p 8) the LPI's six components are:

- "Customs: the efficiency of customs and border management clearance;
- Infrastructure: the quality of trade and transport infrastructure;
- International shipments: the ease of arranging competitively priced shipments;
- Services quality: the competence and quality of logistics services;
- Tracking and tracing: the ability to track and trace consignments; and
- Timeliness: the frequency with which shipments reach consignees within scheduled or expected delivery times".

As we can see, this index measures both quantitative and qualitative aspects. It analyzes, on the one hand, political reforms, the quality of infrastructures and services, all of them related to trade, transport and Customs; on the other hand, it analyzes the performance results of the supply chain for example time, cost, delivery punctuality, traceability, …

The United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT)

It is an intergovernmental subsidiary body of the United Nations Economic Commission for Europe (UNECE) that acts as a focal point within the United Nations Economic and Social Council for recommendations on trade facilitation and electronic trade standards.

Trade Facilitation is defined by the World Trade Organization (WTO), as "the simplification and harmonization of the procedures that govern international trade, considering the procedures that govern trade as the acts, practices and formalities necessary to collect, present, communicate and process the data required by the movement of goods in international trade" (Singapore Ministerial Conference (WTO) 1996).

The UNECE Regional Report on the Global Survey on Digital and Sustainable Trade Facilitation 2021 was prepared under the overall guidance of Elisabeth Tuerk, Director, Economic Cooperation and Trade Division.

This report introduces the Implementation rate of General and Digital trade facilitation measures, by UNECE country and group, 2021 (%).

This index assesses the progress in the implementation of trade facilitation measures and, thus, helps to identify the political, legal, procedural, regulatory and technical gaps that affect the implementation of such measures.

In order to do this, we analyze five aspects based on the United Nations Global Survey on Digital and Sustainable Trade Facilitation, 2021, to evaluate the rate of trade facilitation implemented in the countries analyzed (UNECE, UN 2022 P 4 -7):

"Transparency:

- Publication of existing import-export regulations on the internet.
- Stakeholders consultation on new draft regulations (prior to their finalization).
- Advance publication/notification of new trade-related regulations before their implementation.
- Advance ruling on tariff classification and origin of imported goods.
- Independent appeal mechanism.

Formalities:

- Risk management.
- Pre-arrival processing.

- Post-clearance audits.
- Separation of Release from final determination of customs duties, taxes, fees and charges.
- Establishment and publication of average release times.
- TF measures for authorized operators.
- Expedited shipments.
- Acceptance of copies of original supporting documents required for import, export or transit formalities.

Paperless Trade Cross-Border:

- Laws and regulations for electronic transactions.
- Recognised certification authority.
- Electronic exchange of Customs Declaration.
- Electronic exchange of Certificate of Origin.
- Electronic exchange of Sanitary & Phyto-Sanitary Certificate.
- Paperless collection of payment from a documentary letter of credit.

Paperless Trade:

- Automated Customs System.
- Internet connection available to Customs and other trade control agencies.
- Electronic Single Window System.
- Electronic submission of Customs declarations.
- Electronic application and issuance of import and export permit.
- Electronic Submission of Sea Cargo Manifests.
- Electronic Submission of Air Cargo Manifests.
- Electronic application and issuance of Preferential Certificate of Origin.
- E-Payment of Customs Duties and Fees.
- Electronic Application for Customs Refunds.

Institutional Arrangement and Cooperation

- National Trade Facilitation Committee or similar body.
- National legislative framework and/or institutional arrangements for border agencies cooperation.
- Government agencies delegating border controls to Customs authorities.
- Alignment of working days and hours with neighbouring countries at border crossings.

- Alignment of formalities and procedures with neighbouring countries at border crossings."

World Customs Organization (WCO)/ International Maritime Organization (IMO)/ World Trade Organization (WTO)

A new agreement signed between the WCO, the International Maritime Organization (IMO) and other entities will further facilitate the sharing of information in a harmonized manner, by updating the IMO Compendium on Facilitation and e-Business and mapping it to the WCO Data Model. This updated Compendium is a set of rules on the presentation of data related to the sea, which will allow the integration of Single Maritime and Customs Windows, and greater coordination between customs administrations and maritime authorities.

IMO Secretary-General Kitack Lim stated that "increased digitalization favors greater efficiency which in turn benefits the ship, the port and the supply chain in general".

The WCO collaborates not only with the IMO but also with other bodies. Likewise, it does so with the WTO on some issues such as trade facilitation, customs, valuation of goods and rules of origin and, currently, also cooperates on paperless trade and technology.

They have also recently collaborated on the following report "The role of advanced technologies in cross-border trade: A customs perspective". In this paper they have examined how technology (blockchain and distributed ledger technology (DLT), the internet of things (IoT), and big data, data analytics, artificial intelligence (AI) and machine learning to identify) can promote trade facilitation and help customs administrations to meet their objectives of facilitating trade, ensuring safety and security and fair revenue collection.

This report is based on the results of the WCO's 2021 consolidated Annual Survey and its 4th Chapter on disruptive technologies.

This report is of special relevance to its members because it assesses the implementation of the WTO's Trade Facilitation Agreement (TFA), which aims at facilitating the release and clearance of goods, including through the use of electronic means to exchange data and documents relating to crossborder trade transactions.

According to WTO (2022, p 7) “The TFA plays a vital role in boosting world trade and output and in facilitating trade by simplifying, modernizing and harmonizing the following:

- movement of goods (Article 9);
- release and clearance of goods (Article 7);
- processing time through the use of risk management (Article 7);
- single-window processes (Article 10);
- exchange of customs information (Article 12);
- measures for authorized operators (also known as authorized economic operators, AEOs) (Article 7)”

In this same area, the WCO published in 2019 the Study Report on Disruptive Technologies that includes a series of advanced technologies that have changed the way of working and has had a great impact on customs procedures.

This report summarizes good practices, highlights the challenges and provides guidelines on the implementation and use of the following technologies in Customs:

- blockchain technology
- internet of things
- big data
- data analytics
- artificial intelligence
- machine learning

These technologies will continue to evolve and will include developments that can be used in customs and in supply chains with the aim to facilitate and drive global trade and to ensure proper revenue collection.

Global Cybersecurity Agenda (GCA)

The Global Cybersecurity Agenda (GCA) of the International Telecommunications Union (ITU) provides the foundation and framework for the survey on the Global Cybersecurity Index (CGI) that assesses the commitment of countries to cybersecurity at a global level. This evaluation is carried out through five tools:

Table 1. Position of Spain in the context of international digital transformation

International Organization	Index	Spain's position
OECD	Digital Government Index (DGI) (1º ed 2019)	Spain is in 7th place out of 34 countries. Korea, United Kingdom, Colombia, Denmark, Japan, Canada are in that order ahead of Spain. It should be noted that the OECD as a group of all countries occupies position No. 17.
	OUR data Index (ed 2019)	Spain occupies the 8th position out of 33 countries. Korea, France, Ireland, Japan, Canada, Australia, Mexico are in that order ahead of Spain. It should be noted that the OECD as a group of all countries occupies position No. 17.
UN Electronic Government Survey 2020	E-Government Development Index (EGDI) Supplemental E-Participation Index (EPI).	Spain forms part of the group of countries with a very high rate of achievement at global level. Spain is in the 17th position out of 193 countries with a score of 0.88. Denmark, Republic of Korea, Estonia, Finland, Australia, Sweden, United Kingdom, New Zealand, United States, Netherlands, Singapore, Iceland, Norway and Japan. In the 2nd group with the very high rate are Austria, Switzerland and Spain. Spain is in position No. 36 out of 193 countries with a score of 0.84.
WIPO	Global Innovation Index (GII)	Spain obtains a score of 45.4 points and the 30th position out of the 132 countries analyzed, the 19th among European countries. Spain is positioned in the quartile of best performers in all the pillars (positions 1 to 33), except Business Sophistication, and achieves a specially high rate in Infrastructure, where it occupies the 13th position.
	Logistics Performance Index (LPI). Developed by The World Bank.	Spain obtains a score of 82.8 points and the 17th position out of the 132 countries analyzed.
UNECE	Trade Facilitation: 2021 Survey	Trade facilitation score of 86.02%. Transparency:93,3% Formalities: 95,83% Paperless trade Cross-border: 61,11% Paperless Trade: 96,3% Institutional arrangement and cooperation: 66,67% Spain occupies the 4th position. The United States, the United Kingdom, Saudi Arabia and Estonia are in that order ahead of Spain, which is tied with South Korea and Singapore.

Source: Own elaboration.

- Legal measures.
- Technical measures.
- Organizational measures.
- Capacity Development measures.
- Cooperation.

Taking this index into account, Spain is in fourth place.

Digitalization and Digital Transformation Strategy in the European Union

Continuing our journey to the next level, we intend to look at the progres and digital strategies within the scope of the European Union which, as it cannot be otherwise, is decisively commited to digitalization and, above all, to digital transformation as necessary in the current climate. Although the development is uneven in the Member States, Spain has cosolidated its position at the top of the group, as we will see later.

As we have indicated, regulatory development has been increasing in recent years, as can be seen by analyzing the regulations that have been passed, among which we can highlight, chronologically, the following:

- May 2018: Following the group of measures on digital taxation proposed by the European Commission, The Presidency set out a roadmap on digital taxation.
- November 2018: The Regulation On The Free Flow of Non-personal Data. It provides the framework for the free flow of non-personal data in the European Union.
- April 2019: The European Cybersecurity Regulation (EU cybersecurity law) came into force.
- June 2019: Digital Policy is introduced; the President of the Council Alexandru Petrescu in his press release spoke about the future of a highly digitalized Europe beyond 2020: “Promoting digital and economic competitiveness throughout the Union and digital cohesion”.
- July 2019: The Directive on open data and the reuse of public sector information came into force.

- December 2019: The Council adopts conclusions about the importance of 5G technology.
- February 2020: White Paper on Artificial Intelligence.
- November 2020: The proposed Regulation on Data Governance (the Data Governance Law) is adopted; it will boost data exchange between sectors and Member States.
- December 2020: the Commission presented the Digital Services Law package. This package attempts to regulate the digital space and digital services through standards. It includes the following laws: the Digital Services Law and the Digital Markets Law.
- February 2021: The Council adopted the Regulation establishing the Recovery and Resilience Mechanism. This mechanism is the central axis of the extraordinary measures that the EU is going to establish for its recovery from the economic and social effects caused by the pandemic and guarantees that the Member States undertake ecological and digital transitions to be more sustainable and resilient.
- March 2021: The Commission presented the Digital Compass, which sets out a vision and targets to promote digitalisation in the EU up to 2030. Parts of the Digital Compass are: Skills, Government, Infrastructures and Business.
- April 2021: the Commission published a proposal for a Regulation for the harmonization of rules on artificial intelligence (Artificial Intelligence Law).
- September 2021: The Commission adopted the proposal for a Decision establishing the 2030 Digital Decade Roadmap.
- January 2022, the Commission proposed an inter-institutional solemn interinstitutional declaration on digital rights and principles for the Digital Decade.
- March 2022: agreement between the Council and the European Parliament on the Digital Markets Law. This law intends to set clear rules for large online platforms.

The EU sets connectivity targets for 2025 promoting access to digital technology for all European citizens. The EU's goal is for Europe to be the most connected continent in the world.

The Council adopts the EU's Digital Europe program which will drive digital transformation by providing funding to carry out these processes.

Within the European Union, the Commission is the institution in charge of supervising the level of digitalization in the Member States, for which it relies on the Digital Economy and Society Index (DESI). A findings report is published annually with the aim of helping countries to identify areas of weakness and thus prioritize its aid; on the other hand, in the thematic chapters that it studies, it gathers the most important areas on which to focus.

The European Commission (2021) defines the Digital Economy and Society Index (DESI) as "a composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU member states across four main dimensions: Human capital, Connectivity, Integration of digital technology and Digital public services".

This index has incorporated various political initiatives over the years, the most important of which have taken place in 2021. Within these political initiatives to take into account are: the Recovery and Resilience Mechanism and the Digital Compass of the Digital Decade of the European Union.

As this has caused this index to be recalculated again for previous years, the European Commission made a series of modifications in the 2021 edition to improve the methodology by taking into account the latest technological and political advances. In the end the most important thing is to adapt the DESI to the four cardinal points and the objectives established within the framework of the Digital Compass.

Prior to this change, the DESI index was structured around five dimensions, but it is now structured around four coinciding with the four main areas of the Digital Compass.

The following table shows the structure of the DESI, showing the indicators currently taken into account by the European Commission when designing said index.

This study is based in the time range between 2016 and 2021, a relatively wide and recent period because, as we have seen in the previous section, these years have been the most prolific on the part of the EU in passing regulations related to digital issues, and incorporates the period before and after the pandemic.

Once we identify the dimensions that constitute this index, we can compare Spain's evolution over the last six years with respect to the European Union.

Table 2. Structure of DESI with five and four dimensions

Five dimensions	The four dimensions of the index and Indicator	
Human Capital	Human Capital	At least basic digital skills
		Above basic digital skills
		At least basic software skills
		ICT specialists
		Female ICT specialists
		Enterprises providing ICT training
		ICT graduates
Connectivity	Connectivity	Overall fixed broadband take-up
		At least 100 Mbps fixed broadband take-up
		At least 1 Gbps take-up
		Fast broadband (NGA) coverage
		Fixed Very High Capacity Network (VHCN) coverage
		4G coverage
		5G readiness
		5G coverage. Fifth generation technology standard for cellular networks.
		Mobile broadband take-up
		Broadband price index
Integration of Digital Technology	Integration of Digital Technology	SMEs with at least a basic level of digital intensity
		Electronic information sharing
		Social media
		Big data
		Cloud
		Artificial Intelligence
		ICT for environmental sustainability
		e-Invoices
		SMEs selling online
		e-Commerce turnover
		Selling online cross-border
Digital Public Services	Digital Public Services	e-Government users
		Pre-filled forms
		Digital public services for citizens
		Digital public services for businesses
		Open data
Use of Internet		

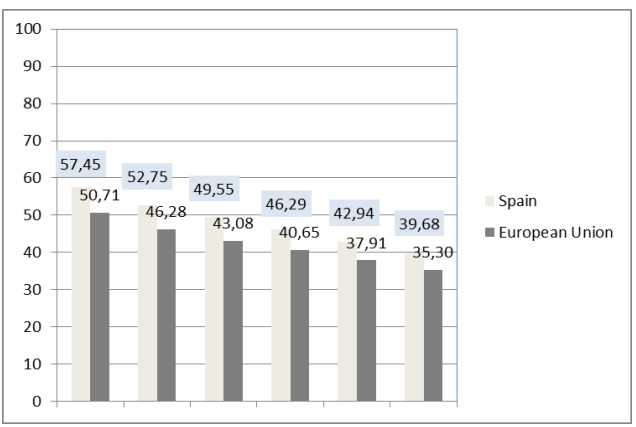
Source: European Commission. Digital Economy and Society Index 2021. DESI methodological note.

As we can see in the table, in 2021 Spain ocupies the ninth position with 57.44 points, and it's placed above the average of the European Union as a whole whose position is fifteenth with 50.71 points. This data shows that both Spain and the European Union have a long way to go in respect of digital issues and digital transformation to reach 100 points, which is the maximum objective required.

Table 3. Position of Spain with respect to the EU. DESI (2016 to 2021)

			Spain	European Union
Digital Economy and Society Index	2021	Position	9	15
		Value	57,45	50,71
	2020	Position	9	18
		Value	52,75	46,28
	2019	Position	8	10
		Value	49,55	43,08
	2018	Position	9	18
		Value	46,29	40,65
	2017	Position	9	18
		Value	42,94	37,91
	2016	Position	10	17
		Value	39,68	35,30

Source: Own elaboration https://digital-agenda-data.eu/datasets/desi/indicators.



Source: Own elaboration https://digital-agenda-data.eu/datasets/desi/indicators/

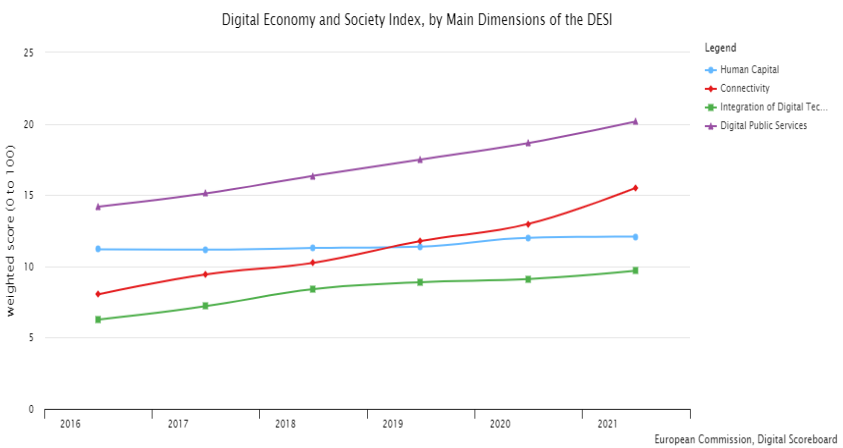
Figure 1. Position of Spain with respect to the EU. DESI (2016 to 2021) in value.

When we take a close look at the data in the following graph of the disaggregated dimensions that constitute the Digital Economy and Society Index (DESI) we observe that from 2016 to 2021 all four have evolved

upwards in Spain, specially in the field of Digital Public Services that includes:

- e-Government users
- Pre-filled forms
- Digital public services for citizens
- Digital public services for businesses
- Open data.

These good results obtained by Spain are a consequence of the default digital strategy applied throughout its central administration.



Source: Own elaboration https://digital-agenda-data.eu/datasets/desi/indicators.

Figure 2. Digital Economy and Society Index, by Main Dimensions of the DESI.

The following table shows that the indicator of Digital Public Services is above the European Union average for all the years analyzed . It should be noted that, in 2020, Spain adopted a specific Digitalization Plan for Public Administrations, passed a law regulating certain aspects of electronic trust services and created the Data Office. In addition, in 2021 it approved the Regulations for the action and operation of the public sector by electronic means. All this contributed decisively to the boost in this area.

Table 4. Digital public services (2016 to 2021)

Years	Value Spain	Value UE
2016	56,76	47,11
2017	60,48	50,51
2018	65,40	54,77
2019	69,99	58,46
2020	74,60	62,86
2021	80,68	68,05

Source: Own elaboration https://digital-agenda-data.eu/datasets/desi/indicators.

Digitalization and Digital Transformation Strategy in Spain

Actions have also been developed in terms of digital transformation in our country. Thus, the Digitalization Plan for Public Administrations 2021-2025 includes reforms aimed at improving administrative procedures and digital competencies, allocating resources for this purpose.

As we have seen previously in this study through the Digital Economy and Society Index 2021 (DESI) of the European Union, Spain starts out in a good position regarding digital administration in relation to other countries of the Union.

This has been possible due to the extensive regulatory reforms that have been carried out, and in particular, Law 39/2015, of October 1, on the Common Administrative Procedure of Public Administrations (Art 16, 27, etc.) and Law 40/2015, of October 1, on the Legal Regime of the Public Sector, which includes the Digital Platform for Collaboration between Public Administrations. We must emphasize that Spain has also created the Ministry of Economic Affairs and Digital Transformation, as the one in charge of supervising the evolution of Electronic Administration, which shows the importance that has been given to this matter.

This powerful stimulus, led by the Public Administration, has meant an important advance in the digitalization of the estate services, reducing costs and response times, and in turn, resulting in higher quality, which ultimately has a positive impact on citizens.

As Spain is a member country of the European Union, all these plans and initiatives are aligned with its Digital Strategy.

The most important initiatives currently being carried out in Spain are the following:

- Spain Digital Agenda 2025, as a boost for Digital Transformation.
- Plan for the Digitalization of Public Administrations 2021 – 2025, a basic element of the Recovery, Transformation and Resilience Plan, for the modernization of Public Administrations, and which specifies the actions to be taken within this field. This Plan is also part of the Spain Digital 2025 initiative.
- Recovery, Transformation and Resilience Plan for the Spanish economy. Under the heading: An administration for the 21st century: it seeks the digitalization and reform of the administration. This Plan is the tool to channel the funds allocated by Europe to alleviate the damage caused by the COVID-19 crisis and, through the investments made, achieve a more sustainable future. To this end, the EU has created new financing instruments known as Next Generation EU Funds. These Funds will grant our country up to 140,000 million euros in transfers and credits in the 2021-2026 period, which will be completed with others in the Multiannual Financial Framework in order to promote reforms in the fields that the European Union defines as priorities.
- Plan for Connectivity and Digital Infrastructures of society, economy and territories. In terms of connectivity and digital transformation, Spain is in third place with 62 points in the DESI ranking in Europe, and is almost 12 points higher than the Union average. This position is a consequence of the determined deployment of very high-capacity networks, and of the commitment to the implementation of ultra-fast broadband connections and digital infrastructures.

Public Administration: Customs Facing the Challenge of Digitalization and Digital Transformation

As we have seen throughout this chapter, the State/Government must take the initiative towards the modernization of Public Administrations, which will bring about, with their boost, that of the rest of sectors.

As we have substantiated throughout the work, our country is well positioned, but it requires maintaining and increasing commitment, because in this field there is no room for complacency, and constant updating is required to remain at the highest level and be able to compete on equal terms with the rest of the actors in the International Community; which requires Spain to

redouble its efforts when it comes to promoting and encouraging digital transformation in all areas.

As an example of the evolution that has taken place in our country in general, and in the Public Administration in particular, we can look at the Spanish Customs as a body belonging to the State Tax Administration Agency, dependent on the Ministry of Finance and Public Administration, and which has been subjected to a profound digital transformation over the last few years.

Both Customs and the Tax Agency on which it depends, have fully commited in recent years to the implementation of new technologies as a basis for increasing efficiency in all their areas of operation, converting them into a global benchmark for the use and review of data collection and processing tools to reconcile traffic security and trade facilitation.

The functions of this body have also evolved over the years, from the traditional one of collecting customs duties and taxes on goods and monitoring the entry and exit of merchandise at our borders, to competencies in matters of smuggling control, customs fraud, illegal trade in protected species, intellectual and industrial property, greater control over health issues with greater cooperation with official inspection bodies (Foreign Health, Animal Health, Plant Health, etc.), safeguarding of protected species in collaboration with CITES, environmental issues, … , all of this aimed at securing the borders while facilitating legitimate trade in the framework of a globalized world.

The objectives of the Customs of the 21st century were established from the earliest publications of the World Customs Organization (WCO, 2008), understanding as the ultimate goal to reconcile traffic safety and security with trade facilitation.

In principle, the main obstacle to trade facilitation is security, understood in its double concept that the Anglo-Saxon language makes easier for us to grasp by distinguishing between “security” and “safety”: security relates to the protection of goods and property and safety to the protection of people.

Over recent years, both in international organizations and in the European Union, progress has been made on regulatory issues in the aforementioned fields. Thus, the EU established, for member states, the obligation to base customs controls on a risk analysis using automated data processing techniques. To this end they established a common risk management framework, which allows for more coordinated customs controls thanks to the use of common rules and risk criteria, the application of priority areas of control and the systematic exchange of information on possible risks between Member States and the Commission.

Currently, the aim is to improve this system with closer and more efficient cooperation with other organizations and economic operators, in order to obtain high-quality data that will allow us to create and improve current processes.

These advances are determined by the digitalization and digital transformation, which has led to the creation and development of different entities and processes that today are decisive in the international logistics flow. Thus, we can highlight the following:

The Registration and Identification of Economic Operators (EORI), Regulation (EC) No. 312/2009 of the Commission, establishes the obligation of Economic Operators to obtain an EORI number and use it for identification purposes in their relations with the customs authorities of all 27 member states.

The Authorized Economic Operator (AEO) and the mutual recognition authorization is a reliable operator whose risk has been previously analyzed with a satisfactory result by customs. Article 5 bis of Regulation (EC) No. 648/2005 states that "you may benefit from the granting of facilitations with regards to customs controls in matters of security and of simplifications as established in the provisions of customs regulations"

As García-Luján, J & Iborra, S (2013) remark: "this figure has transcended the scope of the European Union, and has been incorporated into the Trade Facilitation Agreement of the WTO, signed in Bali in 2013, which accounts for its vital importance in the current framework of international trade relations", where, through Mutual Recognition Agreements, the benefits granted as AEO in one country are recognized in others.

Prior declarations of entry/exit of goods, such as the requirement to submit electronic data before the arrival/exit of goods to the EU (Entry Summary Declaration - ENS)/(Exit Summary Declaration (EXS). Based on this information, Customs will carry out a risk analysis prior to the arrival or departure of the goods, which is currently being updated with the cargo advanced information systems (Import Control System – ICS2).

Promote international customs cooperation to improve supply chain risk management, encouraging all countries to play a proactive role in the development of global standards in relevant multilateral forums. Worldwide, steps are being taken to create a network in support of the international trade system promoted by the WCO, involving the public and private sectors, which would lead to the creation of an electronic international customs network ("e-Customs") that would ensure uninterrupted, real-time, paperless data flow and connectivity.

Improve and promote cooperation between customs administrations and economic operators. There is, among the members of the European Union, real-time collaboration between customs administrations (centralized clearance) and between them and companies, with a view to facilitating legitimate trade while carrying out the necessary customs controls.

All this is endorsed in the regulations by Regulation (EU) No. 952/13 of the Council in which it describes in its Art 6 that "All exchanges of information, such as declarations, applications or decisions, between customs authorities and between economic operators and customs authorities, and the storage of such information, as required under the customs legislation, shall be made using electronic data-processing techniques." Furthermore, Art 16 reinforces the existing cooperation between the Member States with the Commission in the development, maintenance and use of these electronic systems for the exchange of information between customs authorities.

As an example, Spain has developed a data exchage platform based on blockchain technology and artificial intelligence, known as e-Customs. For this, it counts with the colaboration of large telecommunications companies, technology consultancies, financial entities, and official bodies such as the AEAT, the United Nations, or the UK Border Agency, with which a pilot program is being developed to overcome the great difficulties that have ocurred after Brexit.

The Customs Code of the Union (known as UCC) as set out in Regulation (EU) No. 952/2013 of the European Parliament and the Council, October 9 2013, and that came into force on May 1, 2016, is the cornerstone that includes the regulations that govern the community customs procedures. It states that relations between economic operators and customs authorities will be carried out exclusively by electronic means, save for the exceptions included in the EU Regulations on this matter. The deadline for implementation was 2020 but the transitory regime was extended to allow for the preparation of computer systems until December 31 2022 for national systems and December 31 December 2025 for Union systems (Art 278 of the UCC).

The Single Window Environment for Customs entails, on the one hand, the modification in the form of presenting the Single Administrative Document (SAD), and in the admission procedure, as well as in the clearance and release of the goods. And, on the other hand, the adaptation of the Single Administrative Document formalization instructions outlined by the Department of Customs and Special Taxes of the State Tax Administration Agency.

Therefore, the objectives of the Single Window are:

- Centralize documentation in a single database.
- Link between economic operators, the Tax Agency (AEAT), the Border Inspection Services (SIF) and State Ports (PdE) so that they can obtain the necessary information for foreign trade operations.
- Avoid duplication and facilitate administrative processing.
- Ensure the coordination of the different organizations so that only a single positioning of the merchandise is carried out, thus avoiding higher costs.
- Streamline dispatch processing times.

Finally, as the culmination of all these actions that seek to make commercial transactions faster, safer and more efficient in a new electronic customs environment, we arrive to what is known as paperless customs, and other ongoing actions such as e-Manifest, e-Freight etc.

In this framework, Customs must continue to innovate to also combat tax and customs fraud, avoiding intrusive controls in the movement of goods, and tend to surveillance tasks through, for example, container X-ray scanner systems, CCTV cameras, GPS tracking and license plate readers. Security in the exchange of goods can be increased by taking advantage of advances in computer applications and through the comparison of the images obtained, reinforcing control in suspicious cases without undermining the agility of transactions.

As we have indicated, everything is decisively supported by the constant digitalization of all customs processes and the existing cooperation between all the actors involved. On the basis of maintaining security in the exchanges, these are carried out through the creation and continuous improvement of encrypted telematic mechanisms for information exchange, under the umbrella of the use of digitally signed documents which records who signs what when and that cannot be modified without leaving a trail of who, when and what was modified, ensuring at all times of the process the integrity, veracity and accuracy of the information.

The outbreak of the pandemic has caused that in public administrations, and specifically, in customs, the development of digital customs processes have experienced a very significant acceleration not only in Spain but worldwide, which, in the end, is the real area in which any business exchange takes place.

This new framework simplifies customs legislation and procedures for both economic operators and the customs administration, in order to reduce the costs associated with the customs clearance of goods and to respond to commercial challenges; the ultimate goal is making customs regulations simpler, more structured and more efficient, within a security framework, to guarantee greater competitiveness of community customs. All this without hindering the performance of control tasks by the authorities, who must constantly make sure that the Authorized Economic Operators carry out their activities within the required standards and, in so doing, continue to enjoy the benefits that holding this status represents.

Conclusion

The advances that have been made in the field of digitalization and digital transformation have been decisive in understanding the society in which we live today and the organizational and cultural changes that have occurred in recent times, where the foundation is information and its management.

Accordingly, adopting digitalization or not is not a choice today, it is the only option, making a firm commitment to digitalization in all imaginable areas and engaging all levels of society, companies and the State. In terms of scope, our country starts in a good position, as inferred from the analysis carried out in this study of the indices that evaluate these dimensions at an international and European level.

As shown in the Customs and trade example, although it could be transferred to any other field, it would not be possible to work on or understand the current logistics flow without acknowledging the vital role of the digitalization and automation of the processes that articulate the international trade; and also to the cooperation of all participating agents, to make it more agile and efficient, aiming at improving the quality of the service provided to the ultimate recipient, being client or citizen. All this without forgetting the need to maintain security.

Finally, we must bear in mind that for a true digital transformation and integration of the entire society, without excluding anyone, we will need a cultural shift that requires the training and qualification of workers, adapted to new profile demands, and the education of society in the adaptation to the new communication models between individuals, and between them and society, companies or States.

All this, without neglecting the seventeen Sustainable Development Goals (SDG) as part of the 2030 Agenda and counting for it with the Next Generation EU financing instruments planned for the period 2021 - 2026, which include a new Reconstruction and Resilience Fund, one of its four axes being the digital transformation, in line with the european digitalization strategy and Spain's Digital Agenda 2025, with a clear and fundamental objective of promoting a sustainable economic recovery after the impact of the COVID-19 pandemic, through investments that improve sustainability, competitiveness and resilience.

In conclusion, the digital transformation/revolution has led to a vertiginous progress in recent years in all areas of our lives, essential in the fight against climate change; advances that we should embrace without fear, and with which already live the so-called digital natives, those born in this new way of understanding our reality; a change that requires continuous updating and promotion in the development and implementation of these technologies, and dynamic education plans at all levels, which will allow us to be prepared for the future harnessing its full potential.

References

Arvis, Jean-François; Ojala, L.; Wiederer, Christina; Shepherd, Ben; Raj, Anasuya; Dairabayeva, Karlygash & Kiiski, Tuomas (2018). *Connecting to compete 2018: trade logistics in the global economy. The Logistics Performance Iindex and Its Indicators.* Available URL:https://openknowledge.worldbank.org/bitstream/handle/10986/29971/LPI2018.pdf?sequence=1&isAllowed=y.

Brennen, JS y Kreiss, D. (2016). *Digitalization. The international encyclopedia of communication theory and philosophy,* 1-11. URL: https://doi.org/10.1002/9781118766804.wbiect111.

Council of the European Union (2018, May). *Bulgarian presidency roadmap on the digital taxation package*. Nº 9052/18. FISC 2016.

Council of the European Union (2019, June). *Conclusions on the Future of a highly digitised Europe beyond 2020:* "*Boosting digital and economic competitiveness across the Union and digital cohesion.* Nº 10102/19." URL: https://www.consilium.europa.eu/media/39667/st10102-en19.pdf.

Council of the European Union (2019, December). *Council Conclusions on the significance of 5G to the European Economy and the need to mitigate security risks linked to 5G. Nº 14517/19.* URL: https://www.consilium.europa.eu/media/41595/st14517-en19.pdf.

Council, G. (2014). *Protocol Amending the Marrakesh Agreement Establishing the World Trade Organization.* URL:https://docs.wto.org/dol2fe/Pages/SS/directdoc.aspx?filename=q:/WT/L/940pdf&Open=True.

Council, OECD. (2014). *OECD Recommendation on Digital Government Strategies.* https://www.oecd.org/gov/digital-government/Recommendation-digital-government-strategies.pdf.

Data, I. I. (2005). *Oslo Manual.* Guidelines for collecting and interpreting innovation data Paris and Luxembourg: OECD/Euro-stat, na dan, 19, 2021.URL: https://www.conicyt.cl/wp-content/uploads/2014/07/Manual-de-Oslo.pdf.

Declaration, S. M. (1996). *Ministerial Conference*. Organization, 96, 5316. URL:https://www.wto.org/english/thewto_e/minist_e/min96_e/singapore_declaration96_e.pdf.

ESCAP, U. (2022). *Digital and Sustainable Trade Facilitation: Global Report 2021.* URL: https://www.unescap.org/kp/2022/untf-survey-2021-global.

European Commission (2009, April). Commission Regulation (EC) No 312/2009 of 16 April 2009 amending Regulation (EEC) No 2454/93 laying down provisions for the implementation of Council Regulation (EEC) No 2913/92 establishing the Community Customs Code. *Official Journal of the European Union L 98/3.*

European Commission, (2020, February). *White paper On Artificial Intelligence - A European approach to excellence and trust. COM(2020) 65 final.* URL:https://ec.europa.eu/info/sites/default/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf.

European Commission, (2020, November). *Proposal for a Regulation of the European Parliament and of the Council on European Data Governance* (Data Governance Act). COM(2020) 767 final 2020/0340 (COD). URL: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020PC0767&from=EN.

European Commission, (2020, December). *Proposal for a Regulation of the European Parliament and of the Council on a Single Market For Digital Services (Digital Services Act) and amending Directive 2000/31/EC.* URL: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020PC0825&from=en.

European Commission (2021). *Digital Economy and Society Index (DESI) 2021 Spain.* URL: https://digital-strategy.ec.europa.eu/en/policies/desi.

European Commission (2021). *Digital Economy and Society Index (DESI) 2021. DESI methodological note.* URL: https://digital-strategy.ec.europa.eu/en/policies/desi.

European Commission (2021). *Digital Economy and Society Index (DESI) 2021. Thematic chapters.* URL: https://digital-strategy.ec.europa.eu/en/policies/desi.

European Commission, (2021, April). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. 2030 digital Compass: the European way for the Digital Decade. COM/2021/118 final.* Document 52021DC0118. URL:https://eur-lex.europa.eu/resource.html?uri=cellar:12e835e2-81af-11eb-9ac9-01aa75ed71a1.0001.02/DOC_1&format=PDF.

European Commission, (2021, April). *Proposal for a regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (artificial intelligence act) and amending certain union legislative acts.* COM/2021/

206 final. Document 52021PC0206. URL:https://eur-lex.europa.eu/resource.html?uri=cellar:e0649735-a372-11eb-9585-01aa75ed71a1.0001.02/DOC_1&format=PDF.

European Commission: DG Communications Networks Content and Technology. (2021, September). *Proposal for a Decision establishing the 2030 Policy Programme* "*Path to the Digital Decade*". COM (2021) 574. Document 52021PC0574. URL:https://eur-lex.europa.eu/resource.html?uri=cellar:6785f365-1627-11ec-b4fe-01aa75ed71a1.0001.02/DOC_1&format=PDF.

European Commission (2022, January). *European Declaration on Digital Rights and Principles for the Digital Decade.* COM(2022) 28 final URL:COM_2022_28_1_EN_ACT_part1_v1jHP0T9pDHtEAV5q9vMSudtjQ_82703.pdf.

European Parliament, Council of the European Union (2005, April). Regulation (EC) No 648/2005 of the European Parliament and of the Council of 13 April 2005 amending Council Regulation (EEC) No 2913/92 establishing the Community Customs Code. *Official Journal of the European Union* Nº L 117/13. URL:https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005R0648.

European Parliament, Council of the European Union (2013, October). Regulation (EU) No 952/2013 of the European Parliament and of the Council of 9 October 2013 laying down the Union Customs Code. *Official Journal of the European Union L* 269/1.

European Parliament, Council of the European Union (2018, November). *Regulation (EU) 2018/1807 of the European Parliament and of the Council of 14 November 2018 on a framework for the free flow of non-personal data in the European Union.* L 303/59. URL:https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1807&from=EN.

European Parliament, Council of the European Union (2019, April). Regulation (EU) 2019/881 of the European Parliament and of the Council of 17 April 2019 on ENISA (the European Union Agency for Cybersecurity) and on information and communications technology cybersecurity certification and repealing Regulation (EU) No 526/2013 (Cybersecurity Act). L 151/15. URL:https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0881&from=EN.

European Parliament, Council of the European Union (2019, June). Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information. *OJ L* 172, 26.6.2019, p. 56–83.URL:https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L1024&from=EN.

European Parliament, Council of the European Union (2020, December). *Proposal for a Regulation of the European Parliament and of the Council on contestable and fair markets in the digital sector (Digital Markets Act). COM (2020) 842 final.* 2020/0374 (COD). URL: https://ec.europa.eu/info/sites/default/files/proposal-regulation-single-market-digital-services-digital-services-act_en.pdf.

European Parliament, Council of the European Union (2021, February). *Regulation (eu) 2021/241 of the European Parliament and of the Council of 12 February 2021 Establishing the Recovery and Resilience Facility.* Nº L 57/17. OJ L 57, 18.2.2021, p. 17–75. URL:https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R0241&from=EN.

García-Luján, J & Iborra, S (2013) Customs facing the challenge of facilitation and security in international maritime transport. *The new organization of the transport market* (pp. 847-863).

Gartner IT Glossary. 2022 "Digitalization" available at https://www.gartner.com/en/information-technology/glossary/digitalization (accessed 26 april 2022).

Gartner IT Glossary. 2022 available at https://www.gartner.com/en/information-technology/glossary/digitization (accessed 26 april 2022).

Gavilán, I. G. (2019). *La carrera digital: Cómo transformar tu compañía para triunfar en el mundo digital* [*The digital race: How to transform your company to succeed in the digital world.*] ExLibric.

Government of Spain, (2020, October). *Recovery, Transformation and Resilience Plan.* URL:https://portal.mineco.gob.es/RecursosArticulo/mineco/ministerio/ficheros/plan_de_recuperacion.pdf.

Government of Spain, *The Digital Infrastructures and Connectivity plan for society, economy and the territories.* URL:https://portal.mineco.gob.es/RecursosArticulo/mineco/ministerio/ficheros/210204_Connectivity_Plan.pdf.

Government of Spain. *Digital Spain 2025.* URL:https://portal.mineco.gob.es/RecursosArticulo/mineco/ministerio/ficheros/210204_Digital_Spain_2025.pdf.

Government of Spain. Digitization Plan for Public Administrations 2021 -2025. *Strategy regarding Digital Administration and Digital Public Services.* URL:https://portal.mineco.gob.es/RecursosArticulo/mineco/ministerio/ficheros/210127_plan_digitalizacion_administraciones_publicas.pdf.

International Telecommunication Union (2021). *Global Cybersecurity Index 2020. Measuring commitment to cybersecurity.* ITU Publications.

Ismail, M. H., Khater, M., & Zaki, M. (2017). Digital business transformation and strategy: What do we know so far. *Cambridge Service Alliance*, 10, 1-35.

Law 39/2015, of October 1, on the Common Administrative Procedure of Public Administrations. BOE, Nº 236, 02/10/2015. Accessed: 2022-05-28. URL: https://www.boe.es/eli/es/l/2015/10/01/39/con.

Law 40/2015, of October 1, on the Legal Regime of the Public Sector. BOE Nº 236, 02/10/2015. URL: https://www.boe.es/eli/es/l/2015/10/01/40/con.

Matt, C., Hess, T., & Benlian, A. (2015). *Digital transformation strategies. Business & information systems engineering, 339-343*. URL:https://www.researchgate.net/publication/281965523_Digital_Transformation_Strategies. Accessed: 2022-05-28.

Organization for Economic Co-operation and Development (OECD) (2015), *Government at a Glance 2015*, OECD Publishing, Paris. http://dx.doi.org/10.1787/gov_glance-2015-en.

OECD (2019), *OECD Skills Strategy 2019: Skills to Shape a Better Future*, Paris: OECD Publishing. https://doi.org/10.1787/9789264313835-en.

OECD (2020), "Open, Useful and Re-usable data (OURdata) Index: 2019", *OECD Public Governance Policy Papers*, No. 01, OECD Publishing, Paris. URL: https://www.oecd.org/gov/digital-government/ourdata-index-policy-paper-2020.pdf.

OECD (2020), "Digital Government Index: 2019 results", *OECD Public Governance Policy Papers*, No. 03, OECD Publishing, Paris, https://dx.doi.org/10.1787/4de9f5bb-en.

Parliament, E. (2019, June). Directive (EU) 2019/1024 of the European parliament and of the council of 20 June 2019, on open data and the re-use of public sector information (recast). URL: https://op.europa.eu/en/publication-detail/-/publication/a6ef4c41-97eb-11e9-9369-01aa75ed71a1ff J Eur Union, 56.

Rozas, J. P. (2019). *Digital Transformation Is Not Digital*. Kindle Edition, 231.

Tax Agency (2020, January). *Agency Strategic Plan TAX 2020-2023.* URL: https://sede.agenciatributaria.gob.es/static_files/AEAT/Contenidos_Comunes/La_Agencia_Tributaria/Planificacion/PlanEstrategico2020_2023/PlanEstrategico2020.pdf.

The Royal Spanish Academy https://dle.rae.es/digitalizaci%C3%B3n Accessed: 2022-05-28.

Ubaldi, B., & Okubo, T. (2020). OECD Digital Government Index (DGI): Methodology and 2019 Results. *OECD Working Papers on Public Governance*, No. 41, OECD Publishing, Paris, https://doi.org/10.1787/b00142a4-en.

United Nations (UN), (2020). *E-Government Survey 2020*. Digital Government in the decade of action for Sustainable Development. With addendum on COVID-19 Response. URL:https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2020-Survey/2020%20UN%20E-Government%20Survey%20(Full%20Report).pdf.

United Nations Economic Commission for Europe (UNECE), UN (2022). *Digital and sustainable trade facilitation: global report 2021*. URL: https://unece.org/publications/trade.

Verina, N., & Titko, J. (2019, May). Digital transformation: conceptual framework. *Proceedings of 6th International Scientific Conference* "*Contemporary Issues in Business, Management and Economics Engineering*" 2019.

World Customs Organization, WCO (2008, June). *Customs in the 21st century. Enhancing Growth and Development through Trade Facilitation and Border Security*. URL:http://www.wcoomd.org/en/about-us/what-is-the-wco/~/media/WCO/Public/Global/PDF/Topics/Key%20Issues/Customs%20in%20the%2021st%20Century/Annexes/Annex_II_en.ashx.

WCO (2019, June). *Study report on Disruptive Technologies.* URL:http://www.wcoomd.org/-/media/wco/public/es/pdf/topics/facilitation/instruments-and-tools/tools/disruptive-technologies/wco_disruptive_technologies_es.pdf Accessed: 2022-05-28.

World Intellectual Property Organization (WIPO), (2021). *Global Innovation Index 2021: Tracking Innovation through the COVID-19 Crisis.* Geneva: URL: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2021.pdf.

World Trade Organization, (2022). *The role of advanced technologies in cross-border trade: A customs perspective.* URL: https://www.wto.org/english/res_e/booksp_e/wcotech22_e.pdf. Accessed: 2022-05-28.

Young, A., Rogers, P. A (2019). A review of digital transformation in mining. *Mining, Metallurgy & Exploration* 36, 683–699. https://doi.org/10.1007/s42461-019-00103-w.

Chapter 10

Museology 4.0. A New Paradigm Arises from the Integration of Digital Strategies and Metaverse in Museums

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Abstract

Fusing museology and digital technology is a complex task particularly since the recent arrival of the 4.0 revolution and the viralization of the metaverse. New immersive technologies are emerging redefining the boundaries between the real and the virtual. Digital media offers new opportunities to deconstruct many of the perceived social barriers between the public audience and cultural institutions. Museums are places where cultural heritage is examined, archived and explained, presented, made attractive and accessible to everyone. New digital practices are shaping museum thinking, revising the whole concept of museology, stimulating the possibility of providing a better and wider public understanding. This new fully immersive digital presentation will evolve into an integrated multi-dimensional exploration of museum artifacts allowing unparalleled public access and understanding. In this article, we will describe the main characteristics of a new methodology, Museology 4.0. By building revolutionary 4.0 philosophy into the institution, fabric, and delivery of museums and heritage sites we will create a new interface between the public and artifacts. The idea is to take advantage of new media's virtual possibilities in order to create new

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realities, transforming museums into storytelling palaces where unique personal experiences with heritage are made real.

Keywords: heritage, augmented reality, metaverse, museum, communication, artificial intelligence, 4.0

Introduction

The last two decades have seen a remarkable increase in the use of Information and Communication Technology (ICT). The Museum and Heritage sector have provided the fertile ground where ICT has nurtured new more accessible connections to social, cultural audiences, improving their relationship by personalising the visitor experience and enhancing communication (Tallon & Walker, 2008) (Wang, et al., 2008).

Economic and cultural pressures have made the reinvention of the role and relevance of museums and heritage institutions an imperative in the search for new and wider audiences. Technology has proved to be an essential tool in making that happen (Horwitz-Bennett, 2010) (MacDonald, 1997) (Panagiotis, Despina, & Chrysanthou, 2013).

The new millennium saw many cultural institutions increasing their spending on digitising collections to improve archiving, conservation, presentation and accessibility. Whilst this reduced some of the audience's logistical barriers to presentations like time and cost, it did little to break down more complex and intransigent barriers to widening audiences like cultural, educational and social differences (Bourdieu, P.; Darbel, A.; Schnapper, D, 1991).

The recent museological practice IT revolution has initiated the use of online digital resources as a means of improving technological interfaces between artefacts and audiences. Engaging audiences through tablets and smartphones energised new storytelling techniques, making information more accessible. New audience's easy familiarity with digital data is fuelling continuing changes in practice, they encourage and enable Virtual Reality[1]

[1] We understand by virtual reality (VR) an interactive and immersive experience generated by a computer that replicates an environment, real or imagined, and simulates physical presence to allow interaction. These electronic simulations of environments are normally experienced thanks to glasses that are hooked to a computer by a cable. It is important to note that in this case technology replaces the environment with a digitally generated one, isolating the user's vision and hearing, which plunges into a virtual world.

(VR) and Augmented Reality[2] (AR), Big Data (BD) and Artificial Intelligence (AI) to be used as educational tools to help visitors explore new worlds.

New methodologies for presentation are emerging, creating more culturally sensitive narratives that utilise and engage with the age-old human practice of storytelling, making for a more socially inclusive interaction (Gillam, 2017). This article is an in-depth exploration of the achievements of the Philosophy 4.0, and the explanation of each of them, explaining how it is being used in the museum context and how we have proven that they are feasible in the development of a fully immersive experience for museum visitors.

Museums Face the Challenge of Developing Digital Narratives

It is commonplace for museums to be storytellers (Johnsson, 2006). From their earliest days Museums have used different techniques to communicate exhibitions in order to make objects accessible to visitors (Roussou, Pujol, Katifori, Perry, & Vayanou, 2015) (Wong, 2015). Today's IT world offers an important opportunity to museums, as cultural storytellers they can act as a catalyst using their archives to produce social change, using inclusive narratives to break down perceived barriers previously isolated from sections of society (Solari, 2015).

Any narrative needs to captivate the audience's attention in order to achieve a better understanding of presentations. However, new skills are required from curators, such as simpler language, engaging themes and storylines to explain and explore complex issues and to reach out to new audiences as jargon, 'museum speak' and academic language has alienated audiences in the past (Solari, 2015).

New, more interactive museology is required to improve linear exhibitions that utilise classical narratives in order to motivate wider audience exploration and understanding. Reaching this goal requires a massive change in museum thinking perhaps far more than the monumental investments needed to provide a digital technology interface.

It is vital to explore the meanings of objects by constructing discourses, using different methodologies and IT media to reach the widest spectrum of visitors (Witcom, 2016, págs. 580 -589) (Brea, 2007, págs. 151-167). Digital

[2] Augmented reality (AR) is the term we use to define the incorporation of data and digital information in a real environment, thanks to the recognition of patterns through software.

media offers an excellent opportunity to museums to utilise non-linear narratives as a way of offering multiple entries to the same topic. This will create a new level of accessibility by placing the visitor at the centre of a presentation with opportunities to be involved in making decisions that allow deeper participation and further exploration (Gillam, 2017).

Another common feature for reaching out to audiences is the use of convergence in new media (Jenkins, 2008). Applied to a storytelling context it allows a mix of different media, previously used separately. In this way placing images next to texts, animations, introducing a musical thread at the same time makes the visitor feel they are in familiar territory. Whilst in their comfort zone it is possible to use a variety of devices and media to widen the discourse without overlapping the real object.

Just as nineteenth-century museums made architectural changes to accommodate a greater number of visitors who could then access objects (Bennett, 1995), the museums of the 21st century will have to adapt to the new needs of the information society, including additional attractive experiences as something necessary for their survival (Witcomb, 2003, pág. 115).

The Need for a New Museology Brunch - Museology 4.0

Nina Simon's work in 2006 initiated discussion about the need for a new concept for museum's participation using the web 2.0. The use of social networks is creating opportunities for more creative public contribution through their opinions and experiences (Simon, 2018). The emergence of Web 3.0 allowed the integration of large amounts of digital data encouraging museums to share their spaces using different spheres and platforms (Zepeda, 2018).

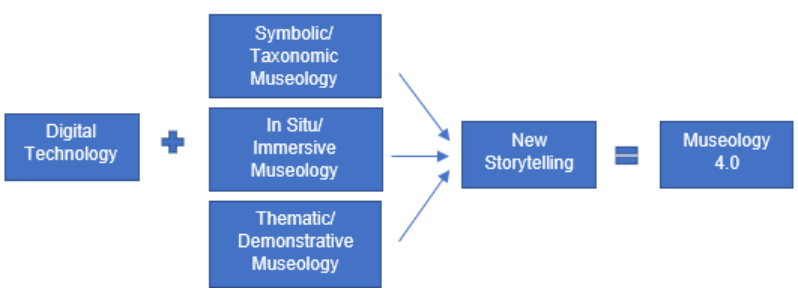
Web 4.0 is used mainly as a means of transforming production through the use of technology, AI, simulation, the Internet of things, the cloud, cybersecurity, AR, BD, analytics and other IT communication systems (Scalabre, 2016). 4.0 technologies enable a symbiotic relationship between the organic and inorganic, humans and machines thereby creating faster and more natural methods of dissemination and distribution of information. Our research programme seeks to establish a different modern concept for traditional museology in the 4.0 era by creating a better dialogue between the museum, artefacts and visitors using IT as a means to enable more accessible human style conversations to take place.

It Is a Purpose to Upgrade Some Museum Analogical Techniques and Practices, Where the Marriage of Intuitive and Cognitive Processes Is Used to Integrate Digital Data into Exhibitions That Allow a Fully Immersive Experience Which Improves Human Accessibility

Our definition of Museology 4.0 uses Raymond Montpetit's approach to possible types of museography as they evolve as examples, where the combining of immersive media and visitor experience create mixed realities (Montpetit, 1996).

It is our contention that Immersive Media (IM) and AI is being used in the museum context to mix a range of traditional museology techniques in order to create innovative dialogues through storytelling techniques. Museums are evolving fast, new methods are blurring the boundaries between the public and traditional museum practices and breaking down social and cultural barriers. Museology 4.0 is primarily a communication breakthrough awakening visitor curiosity by allowing innovative personal exploration and encouraging museum practice to review their communication, teaching and learning methods.

Over the last five years, our programme of research has looked deeply into the early use of Museological 4.0 practice, analysing the experiences of a variety of museums to reveal the implications for future museum practices. Later in our paper, we will reveal the main characteristics of our findings and how we have applied them in some effective tests. Meanwhile, we will explore and explain some of the remarkable examples of museums using 4.0 Technology as an effective communication and information route.



Source: Own elaboration.

Figure 1. Museology 4.0 origins.

As a Paradigm for Museums

The primary use of the 4.0 revolution in museum practice is to facilitate the creation of a more natural relationship between technology, public and museum through the use of differing IT technologies. The extremely large amounts of digital data arising from the Semantic Web (SW) require the use of AI to enable the revision of communication, meaning and teaching methods of museum practices.

Artificial Intelligence and The Cloud

Museum guides are having to change quickly, moving on from analogue systems of audio recordings and paper presentations to IT rich systems that can interact between them and visitor's smartphones, tablets. This is allowing them to customise visitor experiences, adapting them to fit with specific user profiles (Damala, Cubaud, Bationo, Houlier, & Marchal, 2008) (Winesmith, 2017) (Mannion, Sabiescu, & Robinson, 2015) (Hee-soo & Sang-heon, 2017).

Another important improvement has been made by using the building's layout and the centre's Wi-Fi network to enable better facilitation of the movement, location and access of visitors. This allows better visitor orientation to artefacts, assists with the flow of visitors and more effective and creative communication of the mapping of complex interiors, archives presentations (Eghbal-Azar, Merkt, Bahnmueller, & Schwan, 2015, pp. 133-142). Additionally, it is also possible for advanced systems to monitor and use previous visitor behaviour to suggest design of other exhibitions that might be of more interest to them (Eghbal-Azar, Merkt, Bahnmueller, & Schwan, 2015, p. 138) (Cao & Zeng, 2021).

AI systems are being applied as a means of improving practices by increasing the museum's ability to correctly interpret complex external data, learn from it and make any changes necessary to achieve specific goals using flexible adaptations (Kaplana & Haenleinb, 2018). AI, when used in combination with the SW, can enable more interactive multi-media, guides ones that increase access and reveal more clearly information about collections. Thus, Multimedia guides with AI can be considered as the new mediators between the museum and its visitors. They would offer data and information whilst allowing visitors to ask questions, register their doubts or confusion creating more transparency, wide comprehension and higher quality experience of artworks, presentation or archives.

'A Voz da Arte' is an interesting example of how AI was used to increase visitor experience in the exhibition room. The São Paulo Pinacoteca worked in collaboration with IBM by developing a cognitive AI chatbot, one that answers questions in real time, using information from the IBM Bluemix cloud (Next, 2017). Although this approach was applied to a relatively small part of the collection of pictures on display, it represents an early example of the capacity of AI in creating a better quality of access to museums and heritage sites. Since then many museums and institutions have successfully used AI to explore digital collections. The Google Arts and Culture Experiments (Google Arts and Culture, 2018), are effective examples where AI was used in different approaches: Art Selfie is an application from Google with more than 30 million selfies taken to be match with famous works of art (Luo, 2018), Art Pallet, another application by Google, select several colours to show classic and modern artwork that connects with this palette, or the MoMA & Machine Learning application used to match more than 27,000 artworks from the pictures of the museum past exhibitions since 1929.

Another interesting example where AI has been successfully used is "Survivors' Stories," an exhibition held by the Holocaust Museum and the Illinois Education Center (Reynolds, 2019). Here, visitors can ask direct personal questions of 13 survivors of the Holocaust as if they were part of a normal live human conversation. The system shows video projections, similar to holograms, that are created from 20-hour pre-recorded video interviews, using approximately 100 cameras with more than 1,200 questions answered (Illinois Holocaust Museum and Education Center, 2017). AI is programmed to interpret each question, automatically selecting the appropriate piece of video recording to fit the visitor's needs ensuring the response is made in a more human-friendly and emotive way.

Interactivity, Gameplay and Social Experiences

New 4.0 technologies, like AI, are revolutionising public access to the information of museums and changing the ways that visitors interact with presentations, due, in part, to an increase in the use of social network communication and the popularity of games and their dynamics in society.

In the past ten years, social networks have helped museums to become more acceptable and open to the public, removing the cultural and social stigma they associated with them. Museums have radically changed the ways in which they communicate with their audiences by using social media marketing techniques such as 'recommendation marketing' to replace more

traditional methods (De la Peña, 2014, p. 102) (Spiliopoulou, Mahony, Routsis, & Kamposiori, 2017).

On the other hand, the growth of mobiles in everyday life, and how these are increasingly used to play (Rivero, 2016) provide new opportunities to collect information from visitors (Gerrard, Sykora, & Jackson, 2017) and, simultaneously, facilitate the use of games dynamics to provide content and attract new generations to museums.

Video games use of innovative narratives have inspired museum designers to create their own attractive storylines. Games designers have shown their capabilities in to imbuing deeper values into virtual objects while challenging gamers to explore three-dimensional space in search of an objective. This aspect has stimulated museum stylists to create more imaginative narratives in presentations and exhibitions of real and virtual artefacts in actual museums (Muñoz & Martí, 2016) (Ridge, 2011).

These techniques have enabled museums to take a bespoke approach when designing exhibition presentations. The reconstruction of heritage narratives into more didactic, dramatic and artistic stories stimulates users to explore exhibitions more deeply, while the tensions it creates, promote greater understanding of heritage and archives (Andrew, Gonzalez, & Fendt, 2015) (Ioannides, Magnenat, & Papagiannakis, 2017) (Komarac & Došen, 2021).

Through their use of game dynamics to explain scientific processes or historic moments the London Wellcome Collection have become exemplary (Wellcome Collection, s.f.). For instance, the game "High Tea," (2011) encourages users to consider the British Empire's trading in opium and tea to uncover a very dubious period of Britain's imperial history (Ridge, 2011). The game showed very interesting results, with gameplays reaching 3 million, and the half of the plays from the first two weeks of its launch. A full game takes 20 minutes to complete, and the average time spent was 14 mins. For many players the experience was interesting since it facilitated a connection to tea that they hadn't been aware of, but for others it was a fundamental shift in their understanding (Birchall & Henson, 2011).

The gathering of data from the public's use of Applications and social networks is now used to learn from audience reaction, affecting the museum's own new style of presentation. An examination of this trend was carried out by the Metropolitan Museum of Art of New York (MET), in collaboration with the social media application (app) Flickr (Wall, 2015). The project culminated in the publication on Flickr of photographs taken by visitors during their visit to the museum. Simultaneously, these images were linked to the

building plan and projected so that other visitors could consult them while they walked around the exhibition.

In a similar way, the "Storypix" project distributed an App to encourage visitors to add their own voice commentary and opinion on certain artworks, sharing them on social networks allowed visitors to consider other personal perceptions of those artworks (Freire de Oliveira, 2017).This project used content from Europeana, stressing the connection with local heritage. It offered the possibility to display the artworks in the street billboard and banners and interact with them and the audience opinion. The level of personal engagement with young audiences was high. From the app you can buy tickets for the museum or share the stories with your friends and families (Freire de Oliveira, 2017).

Beyond Screens – Use of Augmented Reality and Virtual Reality in Museums

Commercial investment over the last decade has transformed VR from science fiction to science fact, making VR glasses an everyday object in IT culture and society in general. In particular, the use of 3D stereoscopic visual systems, used to track user movements of head, hands and eyes in space and accompanied by fully immersive sound environments have been spectacularly successful in creating unreal or virtual worlds (Billinghurst & Thomas, 2016), and companies as Meta are exploiting this universe, now called metavers (Wang, R. Qin, Wang, & Hu, 2022).

AR systems, by enabling the incorporation of digital data in a real environment, allow users to perceive digital recreations without losing their perception of the physical world they remain in. The AR approach offers a more familiar route to better interaction with data to less well-travelled IT users since it allows information to be included in layers. In this way, information is modified to fit into real space/time without overloading users whilst maintaining the integrity of the original work in the context of a more natural presentation of related data.

Gaming showed how information could be superimposed on the real world, this stimulated museological practice to develop a more accessible interface with audiences. Thus, encouraging visitors to achieve a better understanding of archives, objects, places and their history. In doing so they made the real world more magical (Burdea & Coiffet, 2003) (Osterhout, 2016) (Trunfio, Lucia, Campana, & Magnelli, 2022).

2016 saw the introduction of Hololens[3] glasses, used to facilitate AR devices contact between user and programme. They are capable of combining tangible physical aspects with virtual elements whilst scanning space, thus allowing the user free movement while maintaining contact with the programme. In 2019 the chinese company Nreal presented a cheap version of AR glasasses that are connceted to the the smartphone through a cable.

Museums face a future of new technological challenges; their priority will be to create a more natural mix of real and virtual environments. The generation of a 'mixed space' will allow users to develop more familiarity with their surroundings, ensuring smoother interaction whilst leaving screens free to interact with the real world (Manovich, 2005, pp. 146-147) (Kipman, 2016) (Weiser, 1991).

One of the first museums to incorporate VR technology into its educational program was the British Museum. They offered the possibility of exploring a reconstruction of the Bronze Age from 3D scanned pieces in their collection; here, users could better understand its use in the past (Rae & Edwards, 2016). This was a pilot experience for learning purposes, but the evaluation provided a key opportunity to confirm that VR was of value in any further trials. 80% of surveyed visitors indicated that the experience was very good or good. It was demonstrated to be helpful for family audience to understand the Bronze Age, a complex part of the British Museum's collection.

VR has also enabled remote access to visitors who face physical access problems or those living remote from museums, by offering a 'virtual tour' to people. Google Arts & Culture, collaborated with London's Natural History Museum in the "Back to Life" project where virtual reality brought the fossil collection of the museum to 'life' (Pavid, 2016). The YouTube video of the Rhomaleosaurus Sea Dragon has 523.571 views since 2016, which demonstrates the effect it had had in visitors from home. Most of the comments from the viewers are positive and show the experience had an added value.

In 2017 VR was ready to be implemented in the physical and real museum. An example is the experience developed at London's Tate Modern, focussed on Modigliani's studio (Tate, 2018); The event was part of a more

[3] Glasses of the "view-through" type developed by Microsoft in 2016. Mobile devices with augmented reality – where users look at their mobile screen to see a mix of camera images and superimposed three-dimensional elements – differ from AR "view-through" glasses. These enable a new system of total immersion using three-dimensional elements to increase our natural stereoscopic visual experience.

comprehensive exhibition of Modigliani's work. This was the first time that the Tate used VR in an exhibition. Nine headsets were positioned in the centre. The exhibition was opened to the public the 23 November 2017 to 2 April 2018. The core audience for the exhibition were completely new to VR, with an average from 45 to 65 years old. Although the tests revealed some anxiety about how to use the headsets, the experience was designed to be seated in order that visitors didn't worry about tripping over or handling controllers. The experience was viewed in the gallery by around 3,500 visitors a week. The evaluation revealed a stronger connection with the wider exhibition through this additional interpretative VR layer. It is interesting to mention that the museum confirmed to be an appropriate and meaningful use of technology (MW18: Museums and the Web, 2018).

Similarly, AR has been used successfully in conjunction with tablets and smartphones in projects that demonstrate how museums can benefit from this technology; "Mirages & Miracles" is an artistic digital installation that includes drawings, virtual elements and holographic illusions which are visible in AR using iPad tablets (Lux Valence, 2017). The experience has been very well accepted by the audience and the proof is that it has been exhibited in more than 20 museums from all over the world including the Centre Phi Montreal, Canada or Ars Electronica Center Linz.

"The Lost Palace" is an exhibition using immersive audio theatre at London's Whitehall Palace to recreate an emotional journey using smartphones GPS systems (Richardson, 2017) (Heritage in motion, 2017). That experience was launched as a pilot version in summer 2016 but returned officially in summer 2017. The visitor evaluation conducted of a sample of 198, rated their experience extremely highly. 90% of visitors rated the technology used as very effective, with figures of 88% for its storytelling power; 87% for practical delivery; and 88% for the overall experience (Heritage in motion, 2017).

The use of AR Hololens glasses to increase visitor experiences has begun to flourish in museum presentations and heritage centres; Leiden's Rijksmuseum collaborated with the University of Delft to exhibit the Egyptian Temple of Teffeh (Reuters, 2016) (Belle, 2017); Bovington's UK Tank Museum showed a mixture of missing and actual conserved German tanks from the Second World War (Malley, 2017). AR is compatible with both smartphones and Hololens glasses, both separately and in combination. The Bovington Tank Museum AR experience can be enjoyed with mobile devices and Hololens glasses in an example of the exploitation of multi and trans-media.

Another example of the use of trans-media and mixed realities is the Musée des Plans-Reliefs where Hololens and AI were combined to create an innovative story showing the origins and evolution of Mont Saint Michel, a presentation that can be seen from both inside and outside the museum (Bezborodko, 2018). The visit takes 20 minutes and uses a model from the Mont Saint Michel. The physical visit costs from 10 to 12 €. It is worth to mention that the experience was nominated to La Val Virtual awards 2019.

The continual evolution of technology will enable museums to steadily develop further improvements to their interface between audience and artefact. If museums can develop a multimedia approach that exploits the new generation's familiarity with IT devices, it could create an evolutionary leap in the way museums reach out to new audiences.

The Development of the Museology 4.0

Many of the recent changes to museological practices reviewed above are being superseded as museums recognise the need for further changes to in order to retain relevance, increase visitor attendance and widen use and understanding by younger generations, spcially after the crisis of COVID-19 and the museums lockdown.

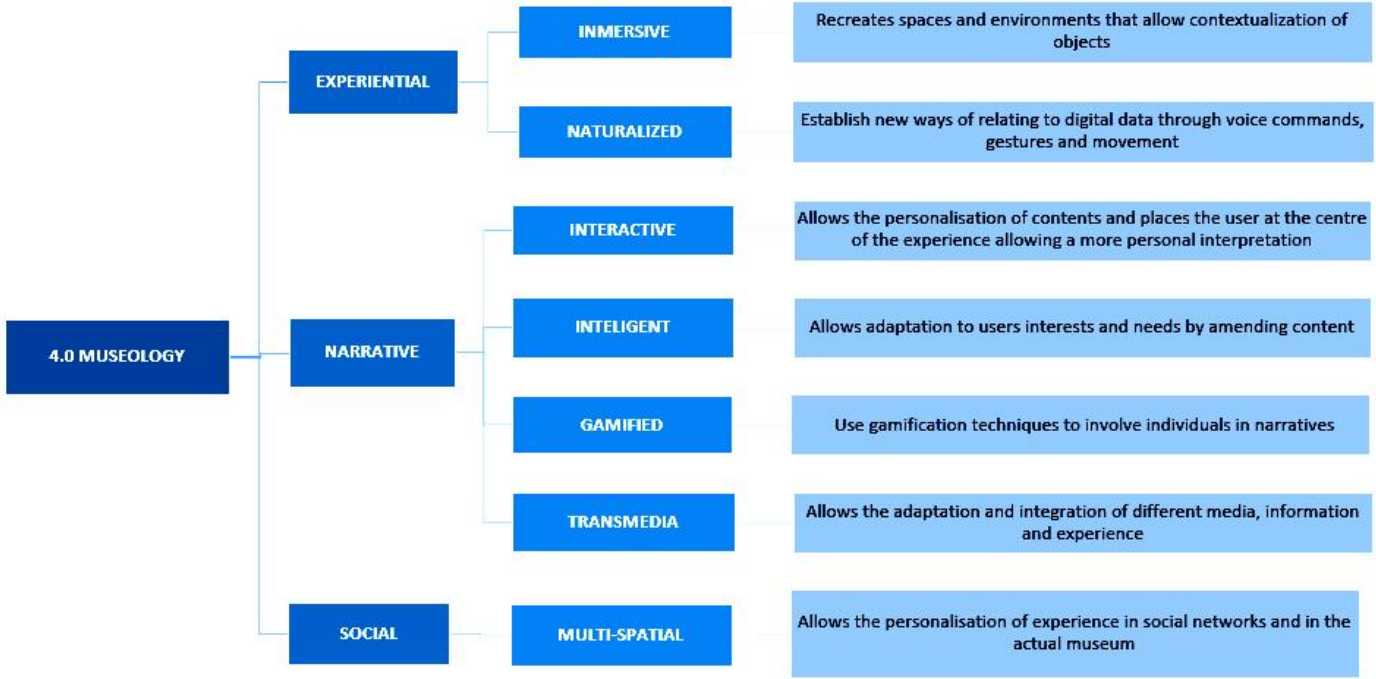
A deep analysis of these approaches since 2015 has enabled us to redefine the terms of reference for what we have named Museology 4.0. (Muñoz & Martí, 2018).

The chart below reveals the relationships, purposes and characteristics that define the major features of the Museology 4.0.

Experiential

Museology 4.0 is in itself Experiential as it is a 'live' definition, reactive to and subject to the constant changes arising from end user's multisensory experiences and designers' interpretations of digital data created by the audience in the exhibition space.

Firstly, as a fully Immersive Experience, AR recreates digital scenarios allowing them to overlap with real space/time, contextualising the exhibition objects, integrating the user and placing them at the centre of the exhibition space and enabling them to interact with their environment.



Source: Own elaboration.

Figure 2. Museology 4.0 characteristics.

The fully immersive experience that VR and AR provides to visitors can transform the experience of media from the classic passive cinematic immersion to a more theatrical-participative dramaturge approach, like in the examples explained in the Musée des Plans-Reliefs or the Tate Modern, and the Modigliani's studio.

Thus, providing a fertile space for storytelling encouraging a magical, emotional and spiritual environment where the user becomes more open, active and responsive to stimuli, like in the experience from the London's Whitehall Palace "The Lost Palace."

Secondly, as a Natural 'everyday' Experience. Digital information is presented to users in a natural way by avoiding the use of screens, the recreation of a familiar environment encourages the visitor to experience the event as if was taking place in their own reality. One example of this is the "Mirages & Miracles" exhibition developed by Adrien M & Claire B.

When digital information is presented trough wearable glasses the user can move freely through the exhibition space allowing them to familiarise themselves and feel at ease with their surroundings. Similarly, gaming has made users well used to interaction with digital information provided in VR and AR scenarios, where it is responsive to voice commands and hand gestures.

Narrative

New media enables the development of different narratives that can be presented to users to improve their experience of visiting museums. Museums use this approach to create new ways to communicate with visitors, personalising content, engaging them in conversations and dialogue which go beyond conventional museological practice and creating more immersive and interactive stories.

Allows Interactivity

It enables the personalisation of information so that it fits with the needs and interests of the visitor's profile. By providing an active role for the user in how that information is used to widen their experience it enhances a museum/visitor emotional bonding while assisting them to make decisions that help construct and improve their experience. In this way, the narrative used remains non-linear, open to user interpretation providing an active role in the configuration of knowledge, similar to the ways in which they manage experiential learning through gaming. This interactivity is shown in the

examples of the ‘A Voz da Arte’ from the São Paulo Pinacoteca or Musée des Plans-Reliefs and the Mont Saint Michel.

Is an ‘Intelligent’ Self-Regulating System

AI’s ability to anticipate future needs by learning from new data gathered as a result of the user’s interactions is growing in response to increases in the capacity and capability that is being gained through the constant evolution of modern computers. This allows narratives to be designed to interact naturally with the user, by providing information in a ‘fluid story,’ one that is reactive to user inputs; this creates a feeling of spontaneity and excitement, similar to a creative discussion between humans. Some examples are explained in ‘A Voz da Arte,’ or “Survivors’ Stories” of the Holocaust Museum Illinois. These interactions can be delivered in response to a look or gesture in the direction of the point of interest.

Benefits from Gamification

Gamification techniques, borrowed from other IT rich environments is an important addition, particularly where it is used to initiate and sustain user motivation for deeper exploration of information and contents of presentations. Having an active role, self-determination, observing their own effectiveness, achieving goals and gaining rewards can be applied to research activity. This could include the collection of artefacts, establishment of collections, creating a collector identity, achieving fame through the use of specific animations and the awarding of emojis. One of the commented museums developing these techniques is the High Tea game from the Wellcome Collection.

Benefits from the Use of Transmedia

The concept of Transmedia includes experiences as part of a media ecology where the main narrative is articulated and adapted through the use of different media in changing situations. In practice, transmedia stories are deployed and presented through multiple media and communication platforms, giving them an opportunity to construct stories from differing points of view. For example, experiences in a room with augmented reality glasses can be reinforced through the addition of complementary content with visitors accessing other information their computer, tablet or mobile phone both during and after the visit, as seen in the Bovington Tank Museum presentation.

Social

Is Socially and Culturally Responsive

In order to survive and thrive museums must achieve relevance, by being socially and culturally responsive both inside and outside the museum. An example of an experience explained is the Storypix developed by Europeana.

To achieve a level of public acceptance and relevance activities need to be presented in a Multi-spatial fashion, offering shared virtual and physical experiences in separate and mixed spaces in the user's own home, in the museum and in virtual spaces.

Wider museum experiences are possible if the presentation's location becomes more fluid and reactive to new spaces, access is easier physically and mentally allowing for variation in the depth of the content's quantity and quality to fit with the user's needs.

Nevertheless, it is essential to preserve the special magic that a museum's unique place in culture and society provides. As a palace of human heritage and achievement, it must also project itself as a 'homely' and human environment, a place where social and cultural interaction is held, stimulated, respected and responded to.

Multi-spatial must mean that delivery is made to audiences in a variety of singular and mixed spaces in doing so it must reach out to wider audiences across social, cultural, educational and generational boundaries.

In order to achieve such a wide degree of relevance to society, it must continue to produce exciting, attractive exhibitions and presentations that can be exclusively enjoyed in a specific fashion only in the building itself. Here, a special dialogue between digital and analogue museological methodologies must be developed and delivered. However, the visitor's experience needs to be unique to and only achievable in the museum itself, perhaps through the inclusion of physical proximity or actual physical contact with objects.

Experimenting Museology 4.0. Some Tests

For three years our research group has developed three experimental tests where we tried to implement all the requirements of the purposed Museology 4.0 in real cases.

We used Hololens glasses to create immersive storytelling in three different scenarios: *Garden*, a test with a reproduction of the Garden of Earthly

Delights by Bosch. *Holomuseum*, an authoring tool to create and visualise Holographic exhibitions, and *Almoina AR*, an experience developed with the Almoina Museum of Valencia about the Roman life of the city from the archaeological ruins (Muñoz & Martí, 2018).

Garden was a sequence of video and animated graphics explaining the Bosch painting with a voiceover. The challenge with this test was to create a storytelling mode that would motivate interest in the artwork, without diminishing the importance of the real object, by adding visual elements, videos and animations projected onto a high-definition, full-size printed reproduction of the famous painting, accompanied with explanatory audio (Muñoz & Martí, 2020).

Holomuseum was an application designed to facilitate the creation and maintenance of different multimedia experiences in any exhibition hall. The application was created to be used by designers and curators when creating exhibitions, and by visitors, in the mode of visualization. In this test we created interactive banners that activated the holograms, an explanatory video of the application that used videogame strategies, to help visitors interact in a natural way through the exhibition hall. The users confirmed that this experience was immersive, interactive and they could share it with the people that accompanied them (Muñoz García & Martí Testón, 2018).

In *Almoina AR* we designed an experience to cover the first steps of the history of the city of Valencia, taking on the challenge of engaging the audience with AR figures and recreations of the lost buildings over the remains of the ruins. The project was conceived around the idea of intimacy, naturality and magic, to appeal to any kind of audience. The experience was designed to be conducted by a fictional video character, acting as a personal historical guide, similar to a mediator. The 'magic' storytelling was designed so that the holograms appeared over the ruins, with animations and music, and there were some hotspots where you could get more information about a particular issue. The test revealed that the comprehension and value of the ruins change completely in the eyes of the visitors, and they moved naturally over the museum (Muñoz & Martí, 2020).

Points of Discussion

The experiences developed using the Museology 4.0 methodologies demonstrates that it will become a disruptive medium in the future of museums and exhibitions, especially for educational purposes, since AR, VR and AI is

demonstrating that it has a very high value when explaining museum contents. It is certainly possible to create adapted storytelling that respects heritage sites and museum contents, while engaging new audiences. Holograms and digital recreations can construct the layers of information so that visitors can better understand the past, procedures and value of artworks and heritage sites.

Still we need to analyse how this museology 4.0 is going to be adapted to the different collections and museums, depending on their collections, mediums, and capabilities.

There are indeed financial, economic and human limitations to the work required to achieve such ambitious aims; major exhibitions and presentations are generally expensive, both to buy and maintain (De Angeli & O'Neill, 2015). Museums also face technological limitations as much of their systems need to be significantly improved: additional IT equipment, hardware, software, apps, presentational means; additional human resources are also needed, new skills, adequate staffing for development, delivery and security. This is a complex ambition and requires a programme of major investment.

The question of the relative value of investment in modern IT techniques arises when integration into what remains a largely conservative, traditional and unchanging environment; are museums really prepared to make such immense changes? Nils Pokel remarked 'Wearables (everyday personal devices we always carry) and the Bring Your Own Device (BYOD) will be a part of life before and after visits to the museum (Uglow & Pokel, 2017).

The future poses major questions for any new investment in the survival and relevance of museums. Enormous changes are required to meet new visitor needs and expectations, create new and wider user access and take advantage of new learning and presentational models. Such changes are required if museums are to reach out to and develop a relationship with new generations without alienating the existing museum cognoscenti.

We are convinced it is possible to overcome some of these limitations, especially if we progress slowly and start by walking audiences through new temporary exhibitions and constructing more accessible narratives that include the use of visitor's own digital resources.

Technology continues to develop more and better devices, which in turn become more available, cheaper and multi-functional. The Technology Market is expected to be filled with cheaper devices (Digi Capital, 2017). Soon, we could reach a point where people will take their own AR glasses to exhibitions, expecting interaction, or to use them in their own homes. Museums must expand their radius of action and improve online access to their presentations. Today's technology offers museums a wide range of

possibilities perhaps already more than they are capable of using to achieve better museum outreach and widen audience development.

With adequate staffing already an issue, additional costs required to recruit, retrain and retain staff with new skills related to the development of apps, software, design and delivery of new technology means any progress will be slow. Optimistically, cheaper production of AR and VR software and devices will mean wider distribution, thus making an economic investment in museum refits more financially viable.

We believe that museums must take action, however small, to remain relevant to an IT-rich culture and society. Museology 4.0 offers a new understanding of AR and VR technology, digital devices, software and human interfaces and perhaps can stimulate and offer assistance in helping museums to take a small step towards a more socially and culturally connected future.

Conclusion

It is clear that the advantages provided by VR's and AR's fully immersive experience offer an important marketing and communication opportunity to museum practice. Using them will help achieve better and wider communication with their existing visitors, build bridges to new audiences and younger IT orientated generations and effect a social and cultural shift in the value of museums to modern society.

Museums face an uphill task to reach out to new audiences in order to remain relevant and accessible to a fast-changing IT conscious society. Museology 4.0 offers museums a specific way forward to assist in the transition between traditional museological practice and the development and delivery of a contemporary digital technology-rich practice.

Our analysis of case studies has revealed the effectiveness and efficiency of the museum's use of digital media in reaching out to new audiences, and the experiences we have developed have corroborated that museology 4.0 is viable. The move to include AR and VR into museum practice is allowing them to move on from a traditional passive contact with users to one where interaction, immersion and familiarity can build a relationship with audiences through the use of a natural conversational approach. This win-win scenario is a two-way learning programme where museums accumulate audience, data and users benefit from more accessible information.

The work we have done in exploring, analysing and explaining differing successful IT rich projects carried out by museums using AR, VR and AI

shows that significant progress is being made in developing new models of practice. These are very early days in the process of the museum take up of digital media techniques, but their success is starting the process of changing previously hardened hearts and minds. Our experiments showed that all these methodologies are applicable in real museums and very well received by audiences.

As more and more museums move into the field of AR and VR presentations it will allow the collection of more performance and audience data. As museums continue to grow and develop better IT skills and experience, research and publication of their success will enable designers to utilise that new data to adapt, innovate and amend museum practices further.

Museums have learned lessons from video gaming, such as the value of interactive dialogue, the benefit of stronger narratives, the dramatisation of scenarios, the use of reactive and proactive systems. The effectiveness of those mechanisms in achieving closer involvement of audiences with museum artefacts is an important factor in helping to shape new communication reach out strategies.

In particular, the use of Hololens glasses in delivering AR has popularised the 'view through' method of interaction between the user and digital data, making for a more dynamic, natural, and exciting user experience. The use in museums of computers, screens, AR and VR enables their practice to develop further, to move on from the more traditional passive, observational and static museum experience previously on offer.

Altered perceptions, both by the viewer of scenarios and the designer in how to present narratives and artefacts have been key to achieving changes in museum practice. Specifically, VR enables the construction of imaginative and fantasy-based worlds, far from the real time/space of everyday experiences. Alternatively, the AR 'view-through' experience enables a different lens helping users to see real objects differently in their own natural space.

The most exciting aspect of this intervention is that it allows presentations to integrate digital information and a physical object in a user-friendly environment. Being in a 'familiar' social and cultural space makes easy learning possible, encourages deeper exploration and further interaction without users feeling they are in a formal 'educational' place.

Through previous examples of practice, we have seen that Holographic presentation, when used in a museum's own space can combine the user's virtual and real experience. Enabling an attractive dialogue that can bind the user closer to the object. Perhaps the most significant aspect of the use of

digital data is that it allows a bespoke experience. AI's algorithms anticipate user wishes and needs, this enables greater flexibility in how and what additional information is provided to the visitor.

Digital data produced by practical experiences of new practice examples is now possible. This is enabling designers to take into account the ways in which users approach objects and displays. Where and when users look, how deeply, how they react to objects both close and far, by observing user's physical responses to information presented designers can adopt and adapt new techniques for more future and better interactive presentations.

Museums will need to retrain existing staff, adding new skill sets in order to take advantage of new data, new digital techniques, new media and new presentational methodologies. This will enable the further development of appropriately focussed information, more effective programming and ensure that the needs of the museum are satisfied and in balance with their ability to provide a product that satisfies the specific needs of new audiences.

It is clear that in the future, the presentation of museum artefacts will benefit from being shown in AR and VR contexts. These new IT techniques offer a survival line to museums in a climate of extreme media and leisure competitivity allowing them to become responsive to the needs of an evolving IT society. The market demands a more personal, emotional and immersive experience, AR and VR provide the means to achieve such a goal.

AR glasses, 'view through' experiences, VR devices, new skills, immersive environments, new equipment all require significant investment if they are to become the cornerstone of communication between user and artefact. Equally, the swiftness of technological advance ensures early redundancy of 'old' technology. Therefore, the timing of investment could be vital to ensure that value for money is achieved when ergonomics, new devices, image fidelity, interactive connection, increased computer power and easier access to cheaper smart devices are taken into consideration.

Perhaps the most exciting revelation that we have made is that symbiosis of the real and virtual elements of presentations is providing fertile ground for more imaginative storylines, stronger interactive narratives, encouraging more emotional and spiritual communication and connections.

It is important to consider the possibilities that digital media offers in the field of transparent communication. We have seen how many museums are already experimenting with new systems of VR and AR, where many of their visions have been enlightened by cinematic experiments with imagination and how once unimaginable science fiction stories and environments have been recreated and brought to life through the use of new technology.

It is our belief that AR, AI and VR are serious new additions to museum practice that have a strong role in shaping social and cultural relevance of museums in the future. Old stories told in a new vernacular can help re-popularise museums, build new audiences among younger generations while retaining existing traditional audiences.

One thing is for sure, technology will continue to grow ever more important to society and culture it is up to museum practice to take advantage of Museology 4.0, Take the time and invest in interactive conversation, build spell-binding storytelling as a way of improving contact and communication with society in the twenty-first century.

References

Andrew, L., Gonzalez, D., & Fendt, K. (2015). Playful engineering: Designing and building art discovery systems. *The annual conference of Museums and the Web 2015.* Chicago.

Belle, E. (2017). *Bringing heritage back to life*. Recuperado el 15 de enero de 2018, de http://erikbele.com/portfolio/hololens-museum-tour/.

Bennett, T. (1995). *The Birth of the Museum.* Nueva York: Routledge Press.

Bezborodko, A. (November de 2018). *The Mont Saint-Michel: Digital perspectives on the model*. Obtenido de Microsoft: https://www.microsoft.com/inculture/arts/le-mont-saint-michel-mixed-reality/.

Billinghurst, M., & Thomas, B. (2016, julio 26). *Introduction to Virtual Reality.* (U. o. Australia, Ed.) Retrieved diciembre 17, 2017, from https://es.slideshare.net/marknb00/comp-4010-lecture-1-introduction-to-virtual-reality.

Birchall, D., & Henson, M. (2011). *High TeaEvaluation Report.* London: Wellcome Trust.

Bourdieu, P.; Darbel, A.; Schnapper, D. (1991). *The Love of Art: European Art Museums and Their Public.* . Cambridge: Polity Press.

Brea, J. L. (2007). *Cultura RAM, Mutaciones de la cultura en la era de su distribución electrónica* [*RAM culture, Mutations of culture in the era of its electronic distribution*]. Barcelona: Gedisa.

Burdea, G. C., & Coiffet, P. (2003). *Virtual REality Tecnology.* New Jersey, Canada: Wiley Interscince.

Cao, G., & Zeng, K. (2021). Design of Digital Museum Narrative Space Based on Perceptual Experience Data Mining and Computer Vision. *2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS)*. doi:10.1109/ICAIS50930.2021.9395789.

Damala, A., Cubaud, P., Bationo, A., Houlier, P., & Marchal, I. (2008). Bridging the Gap between the Digital and the Physical:Design and Evaluation of a Mobile Augmented Reality Guide for the Museum Visit. *3rd International Conference on Digital Interactive Media in Entertainment and Arts*, (pp. 120-127).

De Angeli, D., & O'Neill, E. (2015). A smartphone headset for augmented-reality experiences in museums. *MW 2015: Museums and the Web 2015.* Chicago: Museums and the Web.

De la Peña, J. (2014). ¿Sirven para algo las redes sociales en el sector cultural? [Are social networks useful in the cultural sector?] *Hacia Dónde Vamos: Tendencias Digitales En El Mundo De La Cultura*, 101-112.

Digi Capital. (enero de 2017). *After mixed year, mobile AR to drive $108 billion VR/AR market by 2021*. Recuperado el 03 de diciembre de 2017, de https://www.digi-capital.com/news/2017/01/after-mixed-year-mobile-ar-to-drive-108-billion-vrar-market-by-2021/#more-1617.

Eghbal-Azar, K., Merkt, M., Bahnmueller, J., & Schwan, S. (2015). Use of digital guides in museum galleries: Determinants of information selection. *Computers in Human Behavior*,, 133-142.

Freire de Oliveira, A. (13 de February de 2017). *Art can live anywhere!* Recuperado el 13 de March de 2019, de https://pro.europeana.eu/post/art-can-live-anywhere-an-interview-with-europeanachallenge-winner-storypix-app.

Freire de Oliveira, A. (19 de octubre de 2017). *Europeana at THE ARTS+ 2017: from insights into digital cultural transformation to new creative experiences*. Obtenido de https://pro.europeana.eu/post/europeana-at-the-arts-fair?utm_source=Europeana +Labs&utm_campaign=12d5da6d84-EMAIL_CAMPAIGN_2017_11_02&utm_ medium=email&utm_term=0_935d4e98eb-12d5da6d84-143119813.

Gerrard, D. M., Sykora, M. D., & Jackson, T. (2017). Social media analytics in museums: extracting expressions of inspiration. *Loughborough University Institutional Repository*, 232-250.

Gillam, S. (2017). Spotlight VR/AR: Innovation in transformative storytelling. *MW17: Museums and the Web 2017* . Cleveland Ohio: Museums and the Web. Recuperado el 11 de febrero de 2018, de https://mw17.mwconf.org/paper/spotlight-vrar-innovation-in-transformative-storytelling/.

Google Arts and Culture. (march de 2018). *Unlocking Culture With Machine Learning*. Recuperado el 12 de 12 de 2018, de https://artsandculture.google.com/theme/ unlocking-culture-with-machine-learning/kwKSLHCd3edAIg.

Hee-soo, C., & Sang-heon, K. (2017). A content service deployment plan for metaverse museum exhibitions—Centering on the combination of beacons and HMDs. *International Journal of Information Management*, 1519-1527.

Heritage in motion. (2017). *The Lost Palace, Historic Royal Palaces*. Recuperado el 17 de febrero de 2018, de https://heritageinmotion.eu/himentry/slug-b8d95e6193daf8032ca 31da893c3e59b.

Horwitz-Bennett, B. (2010). *High-Tech Museums: The Future is Now*. Interiors + resources.

Illinois Holocaust Museum and Education Center. (2017). *Survivor Stories Experience*. Recuperado el 2018, de https://www.ilholocaustmuseum.org/abe-ida-cooper-survivor -stories-experience/.

Ioannides, M., Magnenat, N., & Papagiannakis, G. (2017). Mixed Reality and Gamification for Cultural Heritage. Preface. In N. M. Marinos Ioannides, *Marinos Ioannides, Nadia*

Magnenat, George Papagiannakis (pp. v, vi, vii, viii). Cham: Springer International Publishing.

Jenkins, H. (2008). *Convergence Culture: La cultura del a convergencia de los medios de comunicación* [Convergence Culture: The culture of media convergence]. Barcelona: Paidós comunicación.

Johnsson, E. (2006). *Telling tales, A guide to developing effective storytelling programmes for museums.* Recuperado el 13 de febrero de 2018, de London Museums: http://www.crickcrackclub.com/MAIN/TELLINGTALES.PDF.

Kaplana, A., & Haenleinb, M. (2018). Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. *Business Horizons*, 15-25.

Kipman, A. (febrero de 2016). *A futuristic vision of the age of holograms*. Recuperado el 4 de octubre de 2017, de TED talk: https://www.ted.com/talks/alex_kipman_the_ dawn _of_the_age_of_holograms.

Komarac, T., & Došen, Đ. O. (2021). Discovering the determinants of museum visitors' immersion into experience: the impact of interactivity, expectations, and skepticism. *Current Issues in Tourism*. doi:10.1080/13683500.2021.1952941.

Luo, M. (17 de January de 2018). *Exploring art (through selfies) with Google Arts & Culture*. Recuperado el 12 de 12 de 2018, de https://www.blog.google/outreach-initiatives/arts-culture/exploring-art-through-selfies-google-arts-culture/.

Lux Valence. (abril de 2017). *Mirages & miracles*. Recuperado el 20 de enero de 2018, de http://www.lux-valence.com/calendrier/mirages-miracles/.

MacDonald, G. (1997). The Digital Museum. En K. Jones-Garmil, *The Wired Museum: Emerging Technology and Changing Paradigms.* American Association of Museums.

Malley, J. O. (15 de agosto de 2017). *Tanks For The Memories: How Augmented Reality is Bringing an Iconic German Tank Back to Life*. Recuperado el 19 de febrero de 2018, de http://www.gizmodo.co.uk/2017/08/tanks-for-the-memories-how-augmented-reality-is-bringing-an-iconic-nazi-tank-back-to-life/.

Mannion, S., Sabiescu, A., & Robinson, W. (2015). *An audio state of mind: Understanding behaviour around audio guides and visitor media*. MW 2015. Museums and the Web 2015. Retrieved enero 17, 2018, from https://mw2015. museumsandtheweb.com/paper/an-audio-state-of-mind-understanding-behviour-around-audio-guides-and-visitor-media/.

Manovich, L. (2005). *El lenguaje de los nuevos medios de comunicación. La imagen en la era digital* [*The language of the new media. The image in the digital age*]. Barcelona: Paidós.

Montpetit, R. (1996). Une logique d'exposition populaire: les images de la muséographie analogique [A popular exhibition logic: the images of analogue museography]. *Public & Musées, 9*(1), 55-103.

Muñoz García, A., & Martí Testón, A. (2018). Holomuseum: A Hololens Application for Creating Extensible and Customizable Holographic Exhibitions. *EDULEARN18 Proceedings*, 2303-2310. doi:10.21125/edulearn.2018.0625.

Muñoz, A., & Martí, A. (2016). Estrategias de videojuegos aplicadas a la comunicación online de colecciones museográficas [Video game strategies applied to the online

communication of museum collections]. *Al margen.Reflexiones en torno a la imagen* (pp. 147-153). Madrid: Universidad Complutense.

Muñoz, A., & Martí, A. (2018). Holomuseum: A Hololens Application for Creating Extensible and Customizable Holographic Exhibitions. *EDULEARN18 Proceedings*, 2303-2310.

Muñoz, A., & Martí, A. (2018). La necesidad de una alfabetización para el uso de la realidad aumentada [The need for literacy for the use of augmented reality]. *Cuadiernu: Difusión, investigación y conservación del patrimonio cultural*, 55-73.

Muñoz, A., & Martí, A. (2020). New Storytelling for Archaeological Museums Based on Augmented Reality Glasses. In S. Hageneuer, *Communicating the Past in the Digital Age.* London: Ubiquity Press. doi: https://doi.org/10.5334/bch.g.

MW18: Museums and the Web. (18 de April de 2018). *GLAMi nomination: Modigliani VR: The Ochre Atelier*. Recuperado el 2019 de March de 17, de https://mw18.mwconf.org/glami/modigliani-vr-the-ochre-atelier/.

Next, M. (abril de 2017). *Giving art a voice with an artificial intelligence audio guide.* Obtenido de https://www.museumnext.com/2017/04/artificial-intelligence-audio-guide/.

Osterhout, R. (8 de junio de 2016). *AWE Annual AR versus VR debate*. (T. Furness, Entrevistador) Augmented World Expo (AWE). Recuperado el 12 de diciembre de 2017, de https://www.youtube.com/watch?v=7P-rQXiyyrQ&t=1733s.

Panagiotis, Z., Despina, M.-G., & Chrysanthou, Y. (septiembre de 2013). Learning through Multi-touch Interfaces in Museum Exhibits: An Empirical Investigation. (E. T. Society, Ed.) *Educational Technology & Society, 16*(3), 374-384.

Pavid, K. (14 de octubre de 2016). *How to resurrect a sea dragon.* Recuperado el 19 de febrero de 2018, de http://www.nhm.ac.uk/discover/how-to-resurrect-a-sea-dragon.html.

Rae, J., & Edwards, L. (2016). *Virtual reality at the British Museum: What is the value of virtual reality environments for learning by children and young people, schools, and families?* mw 2016:Museums and the Web 2016. Los Angeles: Museums and the Web. Retrieved febrero 17, 2018, from https://mw2016.museumsandtheweb. com/paper/virtual-reality-at-the-british-museum-what-is-the-value-of-virtual-reality-environments-for-learning-by-children-and-young-people-schools-and-families/.

Reuters. (25 de octubre de 2016). *HoloLens to help improve museum experience*. Recuperado el 15 de enero de 2018, de https://www.reuters.com/video/2016/10/25/hololens-to-help-improve-museum-experien?videoId=370256067.

Reynolds, D. P. (2019). Holocaust Memory in the Digital Age. Survivors' Stories and new Media Practices. *International Journal of Heritage Studies, 4*(25), 438-440. doi:10.1080/13527258.2018.1498373.

Richardson, J. (enero de 2017). *New Immersive Heritage Experience – The Lost Palace*. Recuperado el 17 de febrero de 2018, de https://www.museumnext.com/2017/ 01/new-immersive-heritage-experience-lost-palace/.

Ridge, M. (2011). Research into games within the context of museums. *MuseumNext conference 2011.* Edinburgh: MuseumNext. Recuperado el 14 de febrero de 2018, de https://www.museumnext.com/insight/games-within-the-context-of-museums/.

Rivero, F. (2016). *Informe ditrendia 2016 Mobile en España y en el Mundo* [*Report ditrendia 2016 Mobile in Spain and in the World*]. Ditrendia.

Roussou, M., Pujol, L., Katifori, A., Perry, S., & Vayanou, M. (2015). *The museum as digital storyteller: Collaborative participatory creation of interactive digital experiences*. MW 2015 Museums and the Web 2015. Chicago: Museums and the Web.

Scalabre, O. (2016, may). *Embracing Industry 4.0 and Rediscovering Growth*. Retrieved from BCG: https://www.bcg.com/capabilities/operations/embracing-industry-4.0-rediscovering-growth.aspx.

Simon, N. (20 de marzo de 2018). *Museum 2.0*. Recuperado el 12 de abril de 2018, de http://museumtwo.blogspot.com.es/.

Solari, M. (26 de septiembre de 2015). *Creating the inclusive museum through storytelling*. Recuperado el 11 de febrero de 2018, de https://www.museumnext.com/ insight/ creating-the-inclusive-museum-through-storytelling/.

Spiliopoulou, A.-Y., Mahony, S., Routsis, V., & Kamposiori, C. (2017). Cultural institutions in the digital age: British Museum's use of Facebook Insights. *Journal of Audience & Reception Studies, 11*(1), 286-303.

Tallon, L., & Walker, K. (2008). *Digital Technologies and the Museum Experience: Hand held Guides and Other Media.* Lanham: Altamira Press.

Tate. (01 de 01 de 2018). *Modigliani VR The Ochre Atelier*. Obtenido de http://www.tate.org.uk/whats-on/tate-modern/exhibition/modigliani/modigliani-vr-ochre-atelier.

Trunfio, M., Lucia, M. D., Campana, S., & Magnelli, A. (2022). Innovating the cultural heritage museum service model through virtual reality and augmented reality: the effects on the overall visitor experience and satisfaction. *Journal of Heritage Tourism, 17*(1), 1-19. doi: 10.1080/1743873X.2020.1850742.

Uglow, T., & Pokel, N. (2017). How Can Museums Use Virtual Reality? *MuseumNext Australia.* Melbourne: Museum Next. Retrieved febrero 17, 2018, from https://www.museumnext.com/insight/how-can-museums-use-virtual-reality/.

Wall, H. D. (16 de abril de 2015). *Picturing Met Museum through Visitors' Eyes*. Obtenido de https://www.metmuseum.org/blogs/digital-underground/2015/picture-met-museum.

Wang, F. -Y., R. Qin, X., Wang, & Hu, B. (2022). MetaSocieties in Metaverse: MetaEconomics and MetaManagement for MetaEnterprises and MetaCities. *IEEE Transactions on Computational Social Systems, 9*(1), 2-7. doi: 10.1109/TCSS.2022.3145165.

Wang, Y., Stash, N., Aroyo, L., Gorgels, P., Rutledge, L., & Schreiber, G. (2008). Recommendations based on semantically enriched museum collections.(Report). *Web Semantics: Science, Services and Agents on the World Wide Web, 6*(4), 283(8).

Weiser, M. (1991). The computer for the 21st century. *Scientific American, 265*(3), 94-104.

Wellcome Collection. (s.f.). *High Tea*. Obtenido de https://wellcomecollection.org/ articles /high-tea.

Winesmith, K. (2017). *How SFMOMA made it's audio-first, location aware app*. *Museum Next.* Melbourne.

Witcom, A. (2016). Interactivity in museums. The Politics of Narrative Style. En B. M. Carbonell, *Museum Studies. An athology of Contexts* (págs. 580-589). Oxford: Blackwell Publishing Ltd.

Witcomb, A. (2003). *Re-Imagining the Museum. Beyond the Mausoleum.* Nueva York: Routledge.

Wong, A. (2015). *The whole story, and then some: 'digital storytelling' in evolving museum practice.* MW 2015 Museums and the Web 2015. Chicago: Museums and the Web. Recuperado el 11 de febrero de 2018, de https://mw2015.museums andtheweb. com/paper/the-whole-story-and-then-some-digital-storytelling-in-evolving-museum-practice/.

Zepeda, N. (1 de febrero de 2018). *Museo 3.0: No solamente visitantes, sino el personal como usuario*. Recuperado el 13 de abril de 2018, de http://nodocultura.com/ 2018/02/museo-3-0/.

Chapter 11

Digitalization and Business in Marketing with a Purpose

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Abstract

This book chapter defines how to work in multidisciplinary teams, coordinating between areas of the entire organization to carry out the so-called how organizations carry out marketing with purpose, sustainability in strategies, and the actions that are being carried out during the implementation of digital transformation. For this, it is necessary that previously, and before defining the corporate culture, there is interfunctional coordination between the key departments of the companies. Activating purposes means working with long-term approaches and focusing on all areas of responsibility working in alignment to provide complete customer service.

Keywords: marketing, digital business, brand disruption, global society, common good, brands with a purpose, digital transformation, brand impact, coordinated multifunction teams

Introduction

According to the traditional approach, marketing is conceived as the discipline that is responsible for the creation, communication, distribution and exchange

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of relevant value propositions, both for consumers, customers, business partners and society as a whole. Today, brands are moving from one moment of uncertainty to another even greater, where markets are changing, volatile, difficult to predict, inflationary systems, the global supply chain, global health crises, and the global macro environment global context, at a political, economic, social, technological and ecological level, does not make it easier for business models to continue as they have been up to now. In addition, the leadership of the teams in charge of change must be much more transversal in terms of competencies, tasks and functions, holistic, and with much more flexible roles.

Currently, you have to live with agile projects, a habit that should become habitual in any marketing department. Work as a team, without falling into departmental silos that become Taifa kingdoms, It is the way to make good decisions. Thus, the great challenge that brands have today lies in leading teams that work synergistically, far from unique special projects. While it may seem like a daunting task to adopt agile forms of teamwork with roles, synergistic functions, and models with sustainable value propositions, this is the key to being able to stay aligned with customer expectations.

Offering better experiences and responding to uncertainty are the value propositions that companies must provide to their target audiences. The brands and teams that lead the way in integrating agility more meaningfully and permanently into their businesses, by working on training and developing their marketing and sales teams, will be the ones that bring the most value to people. Cross-functional teams with a breadth and variety of skills form the foundation for developing agile marketing operations. As digital transformation initiatives have accelerated in recent years, so has the demand for new skills, and especially the capabilities to deliver 360-degree integrated services, deliver agile value propositions, and better manage the customer experience.

Justification

The progress of digitization represents an advance in people's lives. Technology is a process that has become the engine of many companies, and working aligned around multidisciplinary projects and with a clear orientation, purpose towards the client through all the company's resources, beyond the specific ones of the marketing department, to create greater customer value, is essential.

This research consists of a qualitative study on the importance of interdepartmental coordination for the achievement of objectives in the key departments of the company, and how well-coordinated technology and marketing with a vocation for purpose permeate organizations and facilitate solutions to problems. end customers. Regarding the methodology, in-depth interviews have been conducted with the CEOs of the main companies that are implementing the technology in their departments and key business areas, both nationally and internationally.

Based on the results, a number of important conclusions have been drawn that can help decision-makers in developing more effective strategies implemented among all key departments of the company (1) that digitalization does not it is easy to apply in the same layer and at all levels, or areas of the organization (2) and that the brands that have focused their efforts on the introduction of technology, and marketing with purpose generate greater effectiveness in their relationship with end customers. The design of the qualitative methodology has been done with the integration of a focus group with five participants, in-depth interviews with 20 senior executives and another 12 experts in technology and marketing in an online focus group.

Methodology and Objectives

The methodology to approach this chapter of the manual consists of a process of information gathering and analysis, mainly qualitative, that allows the extraction of concrete data to elaborate conclusions and final results, plus mandatory reading of manuals and reference articles on both marketing and inter-functional coordination between departments and people. These stages have been defined by the previously established objectives, together with the contributions collected in the process of reviewing a wide literature, which has been basically supported by JCR and SJR papers, as well as doctoral theses on the topic in question, as well as through numerous in-depth open interviews with marketing and general management professionals, on the different key topics of the research.

Reports from marketing departments, as well as attending seminars on digital transformation models, have been a crucial part to work, initiate and develop the model, as well as to obtain clear conclusions about this sector and how technology and digitalization has been evolving, during the last 5 years in the business sector and mainly marketing as corporate culture in well aligned strategies generates better results for the final customer. The

objectives are defined in relation to the strategies of the business model, so they have reason to be in relation to the methodology that has been used.

The primary sources used are the following:

- In-depth interviews, granted to the author of this chapter, by professionals in the marketing sector and the global sales business, as well as CEOs mainly of multinational brands with a turnover of over one billion euros.
- Industry information in specific areas and cases: interviews granted to obtain new, interesting, relevant, and unique data for the research.
- Process and phases: In-depth interviews, with key questions concerning the information needed to work and conclude the research with objective and current results on a sector that is still booming and much remains to be defined.

The secondary sources used in this study are the following:

- Documentary study: Books and documentation already mentioned in references section.
- Interviews collected from web pages of the sector: current papers, this review being scarce due to the current nature of the subject to be treated.

The direct sources are:

- In-depth interviews: face-to-face, open, and in-depth interviews, as well as through the Facetime application. The panel consisted of high-consumer organizations and startups, as well as marketing consultants, as mentioned above with high turnover in their key performance areas.
- Sample size and distribution: numerous interviews. Multi-stage sample distribution stratified by business type, including mainly large brands and SMEs with high turnover.
- Sampling error is negligible or non-existent, with a 99% confidence level. The time period of these interviews has been conducted by the researcher from November 2021 to May 2022. The design of the qualitative methodology has been done with the integration of a focus group with five participants, in-depth interviews with 20 senior executives and 12 other technology and marketing experts in online focus groups.

The research objectives, both specific and general, are one of the most important starting points of this research work. What we propose as objectives are the answers that later and throughout the text, specifically in the conclusions and results section, we try to achieve in order to solve a situation that we envision as an opportunity to shed light on a specific sector. From the application of the observation and qualitative techniques, we try to respond both to these specific objectives and to the more general ones, both have been designed and commissioned to give unity and conductive thread to the whole work.

Interdepartmental Functions Applied to Marketing Strategy

It refers to the processes that companies must manage properly to successfully adapt to the new digital transformation landscape. In order to manage this change, companies must transform most of their key processes and resources, where the synergies between departments and their roles and functions must respond in an even more integrated way to the final result that they offer to customers. endings. Currently, people become a fundamental asset to achieve digital transformation in the companies.

Most companies are adopting a transformation strategy that allows them to digitize their business ecosystem, in order to compete in an increasingly innovative and disruptive world. However, the significant gap between failure and success rates reflects a lack of common understanding of what digital transformation really means. The lack of clarity in the definition leads to ambiguous strategic decisions. This new situation implies revealing changes in the ways in which we relate to each other, live and work. Scwap (2017) states that "this revolution involves a profound and systemic transformation, where the necessary levels of leadership and understanding of the changes underway, in all sectors,

Currently, companies must address new challenges, within this industrial panorama in which the relationship between machines, human talent and ethics takes on a special role in the interpretation of huge volumes of data, the design of new business strategies, as well as the effects that are taking place in the global society. In this context, it is not clear that the more traditional business leaders are in the necessary line to manage these new business models (Quintana, 2015), which leads us to consider leadership as a key factor in digital transformation. Nor can it be said that the systems that work in the traditional model of team management fit into this new model of digital

transformation, and that they can be applied in a new environment where to manage uncertainty, is key in marketing departments (Bock, 2015). Today, the global context has accelerated the digitization process in people's daily lives, where the gap between profiles that develop digital skills and those that do not is widening. The most efficient teams will be those that are capable of combining digital skills at a native level, with strategic skills in terms of a global and structured vision of the new reality.

"Digitization represents a challenge for organizations, where to achieve its optimal implementation, companies must invest in staff training, empower employees, change organizational culture, and adopt a key role of analytics within the company, hiring leaders who actively support models that include digitization" (Ancarani and Di Mauro, 2018). To increase the success of these digital transformation processes, new organizational capabilities and roles are required, which leaders must assimilate, and which have very complex implications for both the company and its employees (Wang et al., 2016). The digital initiative imperatively implies that organizations make strategic changes in order to improve not only the individual competencies of their workers, but also the coordination of people, processes and technologies (Desmet et al., 2015; Dörner and Meffert, 2015). Therefore, the changes that the organization is capable of making thanks to the advantages offered by new technologies must be complemented with changes in organizational structures, management approaches, organizational behaviors, as well as operating cultures (Wade and Marchant, 2014; Kohnke, 2017).

Currently, companies and society in general are immersed in a process of digital transformation, which conditions all types of activity and interaction, whether business or social. In this new context, the Spanish economy is in the process of digitization, like other economies in the euro zone, or North America (Lombardo, 2015). This process is considerably conditioning companies from a global point of view, and not only on their operations or internal processes, so adapting to increasingly digital market environments is currently a challenge for all companies. To this we must add that this change in the way work is done has significant implications for organizational behavior, corporate culture, talent recruitment,

The potential benefits of digitization are multiple and include not only increases in sales, productivity, innovation or value creation, but also the emergence of new ways of interacting with customers. Furthermore, without the transformation of existing companies, the economic and environmental challenges of the future cannot be solved in a sustainable way (Bican and Brem, 2020). This work aims to analyze the impact that the external and

internal context of digital transformation is generating in talent management in organizations (Gallardo-Gallardo et al., 2019), where among the factors that are changing the most in organizations, the organizational culture (Bendak et al., 2020). If we analyze the moment of change at all levels that is happening today, and in particular in business models both globally and locally, a great transformation can be seen from simpler tasks such as communication and entertainment, to complex tasks such as financial transactions. It is increasingly common to see connected cities, through electronic assistants, networks and high-speed connections, or schools permanently migrating to online education.

We can practically say, without fear of being mistaken, that the last decade defined the bases of the digital transformation, so that in the current decade, redefine and shape the new lifestyle in society. It is increasingly common to see connected cities, through electronic assistants, networks and high-speed connections, or schools permanently migrating to online education. It is evident that the process of digital transformation will vary depending on the country, and the degree of impulse that it shows to innovate and evolve, but in a general way it can be affirmed that the new digital societies are having a positive impact on the business sector (Ruiz Alba et al., 2019). Under these circumstances, it is necessary to adapt both internally and externally the operation of our businesses, companies or organizations, because, by understanding human behavior around digitization, more reinforced value chains emerge, as well as multidisciplinary teams working for a same goal. In this way, it will be possible to guarantee the continuity of our key groups of clients, offering them an experience that is even more personalized for them.

The COVID-19 pandemic has marked a milestone in human relations, and being even more specific, in the relationship between companies and their customers, more digital and far from showing a tendency to disappear, it has accelerated the digitization process in mercantile entities that were just beginning to experience it, even in sectors that could hardly be imagined. We must be aware that it is an obligation to act in time in the decision-making of a company to ensure its adaptation over time, and in this facet the marketing departments stand as an active engine in the innovation of the models of creation of value, where digital transformation allows these business models to be modified and adapted (Kotarbe, 2018).

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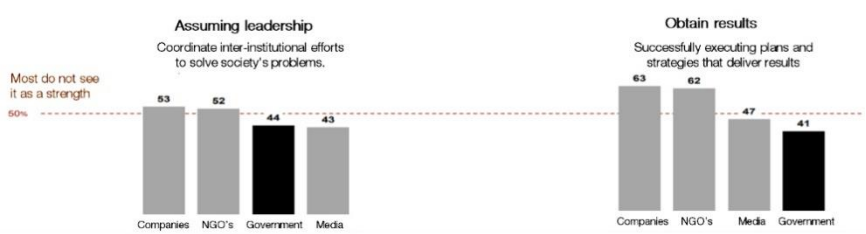
In this context, digital transformation is defined as the process that consists of a set of steps through which organizations seek to transform and create new business models and corporate culture through digital technologies and multidisciplinary teams. This transformation begins from the top management of the companies, that is, the executive board, shareholders' meeting, or the business owner, who provide the resources, ideas and the most suitable work environment so that the teams involved can develop a full process. of transversal and multidisciplinary skills, as well as living in a shared way the transformation and the factors of change. Senior management must be firmly and actively involved in the different areas of the business, seek to generate competitive advantages, and interpret and design strategies where people and their digital habits are listened to and taken into account. Digitization makes companies innovate in order to continue to be successful and competitive in the present and future.



Source: Edelman Barometer. 2022

Figure 1. Companies are considered the institution most capable of solving society's problems (% stating that each dimension is a strength of the institutions).

For this, it is necessary to focus on 2 areas that are configured as crucial:

1. Analyse the digital experience of customers: The ideal is to pay attention to how people make purchase decisions, where and when, in addition to identifying how we get customers to connect with the brand, and recommend us, either because of the quality of the product or the service, the experience of use or purchase, as well as the points of contact between the brand and the customer.
2. Generate efficient revenue models, facilitated by technology: Seek that the business adapts to digital channels, generating an omnichannel sales model, offering products and services through hybrid channels, and measuring where the traffic comes from and the phase of the funnel or conversion funnel in which customers find themselves, from notoriety, to interest, desire, purchase, or loyalty.

The framework of the digital economy can be defined as a new social, ecological system, in terms of sustainability, political, legal, technological and economic, characterized by an intelligent space that is made up of information, access instruments, data processing data as well as communication capabilities. The mechanisms of this economy are the information technology industry, electronic commerce between companies, the digital distribution of goods, services and content, as well as support for the sale of tangible goods, especially systems and services that use the Internet. Transforming the culture, adopting new organizational models, is of utmost importance. This requires that the organizational culture be as open as possible to new ideas, processes and operations,

Research and development, the most important innovative activity of a company, is an important capability, as well as the engine of brand value. The marketing literature has been engaged in finding an adequate definition of brand equity ever since the concept was first floated in the 1980s (Aaker et al. 1996; Yoo et al., 2012; He et al., 2020). It could be said that the value of the brand summarizes the knowledge of products and services by companies for customers. Successful innovations contribute to strengthening brand associations, creating and supporting brand points of difference, increasing attitudes towards them, ultimately improving brand equity as well as profitability (Brexendorf et al., 2015).

Once the previous points have been analyzed, the strategy must focus on the set of steps and actions to be followed, in a sequential manner, to develop an orderly digitalization process in the organization. The main steps are:

1. Design the digital strategy, aligned with the global strategy dashboards, design criteria to focus the organization's objectives in a digital environment, define key talent in the organization according to the thematic areas of specialization that contribute to a global strategy framework, which includes external agents, such as advisors, observers, experts, or other companies, with the goal of determining the entity's situation, what it needs to improve, and how it is going to do it.
2. Train strategic talent with digital skills: By strategic areas, efficient training programs must be developed that allow generating a global, structured, digital, and more operational vision with key people, in addition to contributing to the learning of basic knowledge in an organized, orderly and continuous manner, in order to raise the degree of global digital knowledge, gradually applying it to the entire organization.
3. Organization and autonomy in work teams: In specific areas to coordinate and structure continuous improvements and deviations from strategic plans with their own criteria, since in this way the exchange of innovative projects is facilitated, with a growth perspective both in internal projects of the department itself, as synergistic with the external ones of the entire organization.
4. Agile processes and ways of working: To launch pilot projects, carry out initial tests, and obtain data. In addition, the strategy must be interpreted for those more viable products and services, which can help us in the phases from exploration to exploitation, seeking improvements in the experience, in real time, for our clients, developing new hybrid and digital sales channels. The idea is to generate a flow between the brand and the client, measuring the economic part in real time so that it allows the company to sustain itself in the digital economy.
5. Continuous measurement for improvement in our organizations: Measure the capabilities and conditions for receiving and storing data, both external and internal, from primary or secondary sources, structured and unstructured, to facilitate decision-making in any of the areas of the organization that needed it. The digital age lowers the barriers to entry, and forces companies to innovate at an agile pace so as not to disappear. To innovate, we need people with "intrinsic" rather than "extrinsic" motivation.

6. Role of the CEO: It involves leading a process of cultural and organizational change, which progressively reduces hierarchies, which gives teams much greater autonomy and independence, redeems all information for global access to the entire organization, and reduces tension traditional hierarchical models.

When the functions of the strategist work in silos, cross-functional coordination is difficult and it is more difficult to create adaptive capacities (Aaker, 2009), where some areas with independent functions lack the intention of working with other departments. If business units work uncoordinated in different directions, conflicting goals can be generated and each area ends up functioning as a Taifa kingdom. This situation can lead to visible confrontations, but there is also the risk of invisible problems in the form of hidden costs or negative implications for customers. Interdepartmental conflicts can arise from an incompatibility of common responses and goals.

Therefore; cross-functional coordination (or IC) becomes crucial to business success. Each person, in any function, can contribute to the creation of value for customers, cooperating in the development of a sustainable competitive advantage. It is widely accepted that creating value for customers is not the role of a specific business unit, but of anyone within the organization. In this sense, some authors found that CI can lead to innovative ideas driven by the client. Working in collaboration can be more beneficial than working in silos, an aspect that requires developing both internal relationships within the company and business-to-business relationships with stakeholders. Nevertheless, relationships are not enough since skills and abilities of the actors involved are also needed. In reality, service innovation requires specific knowledge and skills, but also IC management (Tajeddini et al., 2017).

Once the work teams have been defined, the marketing strategy and the generation of new hybrid technologies that break into the organizational model are defined. The changes in the use and consumption of digital after the COVID-19 pandemic has accelerated the adoption of technology in people, which influences the way in which they relate to their brands. The marketing 5.0 concept defines this aspect as the "link between technology and society" (Kartajaya et al., 2021). Brands can create a more personalized relationship with their customers, listen to them through their own channels in real time, and converse with them. In this way, configure, create, innovate and improve the user experience in products,

The present and future challenges lie in how to create and establish a relationship with consumers through platforms, combining messages and

channels for the different generations that will show very diverse behaviours, preferences and attitudes. Knowing how to reach each of these groups with ad hoc innovative value propositions is the real challenge for brands. In this sense, technology adds value to marketing through different components (Kotler and Kartajaya, 2017):

1. Data Marketing: It is the basis of any decision-making process, selecting the data management that allows analysing and interpreting the information, in order to create optimized marketing solutions. In the age of digitization, daily activity generates more data than ever, and we have to be able to know how to use them to design more effective strategies for our clients.
2. Predictive Marketing: Use of time series analysis, based on algorithms and predictions of market and consumer behaviour, with the aim of making marketing forecasts. This approach is effective in saving time and costs for companies, since they can create target models of potential markets, and act according to those patterns.
   Sensors, chat bots, machines and equipment generate huge volumes of data on the Internet of Things, while almost every process we use leaves digital footprints that offer important information for the design of new strategies. Interpreting the data by the marketing teams, it can be clustered and ordered by data structures, to discover which behaviour patterns would repeat and are interesting for our current and potential customers, and which ones would not. With this knowledge, more effective decisions can be made. In this way, companies that make good use of that footprint or records left by their customers or new ones can promote innovations in their value propositions, more adapted to the wishes of customers.
3. Contextual Marketing: It consists of analysing the physical and motivational environment of the consumer, which is shown through the interfaces available on their social networks, platforms, and applications of daily use. Contextual marketing determines user actions in real time with the aim of offering the right message to the right person at the right time and term. It allows a high degree of personalization, which optimizes marketing and communication campaigns to achieve better results. Contextual marketing has existed for years, but it is gaining importance thanks to machine learning and big data. Due to the information that these technologies offer, a hyper-segmentation can be achieved that helps our message reach the public

more akin to the service or product that we offer. is advertised, and in a context in which there is a high predisposition for conversion to occur. This type of marketing quality places the user at the centre of the strategies. By putting the scale in context, the consumer becomes the centre of the marketing strategy, comes first. This generates more appropriate content for it, since it adapts to the environment and the importance of quality prevails over intrusiveness. By default, it tends to increase consumer confidence in the brand through more attractive and interesting content and achieving greater performance in the effectiveness of marketing and advertising campaigns. This type of marketing strategy considers emotion and context and how these factors influence purchasing decisions, this is when communication flows with the audience, because it appears on their favourite channels and in the right context, so it is improving the customer experience.

To implement content marketing, in digital campaigns you must know the audience

4. Augmented Marketing: Use of technologies that make it easier for brands to use tools that improve interaction with their customers. In this group you can find everything from chatbots to virtual assistants, which offer customers support that is generated through digital interfaces. Offers brands the opportunity to transform a static object, into an immersive experience in reality, and with 3D animation. It provides the consumer with a different experience by uniting reality with images and virtual objects with which to interact in real time, an interaction with the user that allows them to have a more real experience with the brand. Normally, the fact that the user interacts with their environment and with virtual elements, promotes the surprise factor that helps to generate more top of ming of the action and the brand.
5. Agile Marketing: It fits the participation of flexible and functional work teams, which can react to internal and external environments to create efficient and effective marketing campaigns. When we prioritize customer and business needs, we create more targeted and relevant marketing programs. Is a tactical marketing approach in which teams identify and focus their collective efforts on high value projects, complete those projects cooperatively, measure their impact, and then continuously and incrementally improve the results over time.

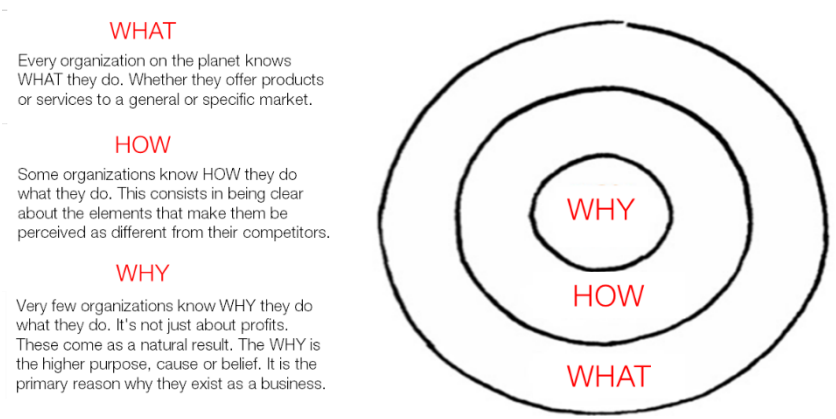
Currently, the model just described is subject to constant revision and renewal. Several decades have passed since brands began to dispense with marketing strategies aimed exclusively at selling, or simply not generating stock, to focus on people's wants and needs, and on the solution that is going to be offered to them. to offer.

Today there are new demands and challenges, which consist of:

- Identify, anticipate, and respond to the needs and desires of people, with a target profile.
- Define customer-oriented experiences, establishing deep and lasting relationships between brands and users, based on loyalty, empathy, and the generation of frictionless experiences.
- Build and configure strategies that generate a tangible competitive advantage, while providing real value, which are also perceived in the market as such: innovation, commitment, and sustainability.
- Execute true and relevant experiences with the client, through the analysis of their behaviour data, and the monitoring of analytics, as a fundamental discipline in marketing strategies.
- Concern for brands in knowing what the customer wants, and making the unique selling proposition useful and valuable, improving it through active listening in all phases of the brand-customer relationship. This leads to the expansion of the traditional "fourfold" scheme: the new person-centric marketing model gives rise to new processes, which in turn generate dynamics that increase profits, to the extent that strategies, reviewing costs and necessary resources, can be better adjusted to the real demand for the product and to market conditions, depending on the profitability obtained. The most important change is that the brand offers people an experience above all, within a space that surrounds the product and that aims to reflect the values and personality of the brand itself. Presence and presentation are vital when it comes to integrating, in physical and online stores, the arguments aimed at provoking the purchase decision. In this way, both physical points of sale and electronic commerce platforms coexist today in a hybrid or mixed scenario, which is reflected in the notion of omni channel. This scenario also highlights the experience and recommendation process that marketing has undergone in its 5.0 stage. (Ayestarán, 2021).

Reinvention and business go hand in hand in the areas of marketing, since for innovation to occur there must be endogenous elements powerful enough to drive changes in the habits and behaviors of society. The circumstances after the pandemic have facilitated these changes in the value propositions of companies. Levers that have activated the economy and digitization have been promoted, and the focus has been placed on transforming sectors and business models as a whole. The following image shows the orderly process that we must carry out to create a purpose that is relevant to the consumer and legitimate to the brand.

When the marketing communication of a brand is oriented to a product or a service, people receive a quantity of information related to the characteristics, benefits of these without focusing on the real purpose. In this case, we communicate directly with the part of the brain that controls behaviour, allowing people to make instinctive decisions. The main objective of the tool is therefore to specify the what for (or the why) of our Value Proposal, once that objective is clear and defined, it is when we move on to the middle circle, namely how we are going to do it. This is the circle of capacities, resources and supports that we will need. In the last circle, the outside appears the "Whats" what the action that we intend to work on will consist of.



Source: Own preparation

Figure 2. The golden circle.

Start with the central circle and define our Why. What are our values, principles or purposes, why have I had this idea and not another and why should our target audience be interested. It is important to work with people's

dreams, values and desires to inspire action. Then it goes to the middle circle, how are we going to carry it out, what are the methods, techniques, processes and strategies that we will try to apply to make that proposal a reality. The third moment, the outer circle, consists of thinking about the products or services that we are going to offer.

The golden circle is applied to the organizations to know in which objectives they have to focus their efforts and how to do it, therefore, it gathers several elements so that it can be carried out, since it is a way of thinking, acting and communicating that accesses to inspire, the emotions and the brain especially, play a crucial role.

According to Sinek (2019), "the levels of the circle correspond to the major levels of the brain. Our brain is segmented into different parts, one of them is the Neo-cortex which corresponds to the outer level of the golden circle (what). It is responsible for all acts, rational and analytical thoughts and language. The inner devices of the golden circle (from outside to inside how and why) match the part of the brain called Limbic, which is responsible for human behavior, decision making, feelings and trust" (Sinek, 2019).

The Time of Purpose

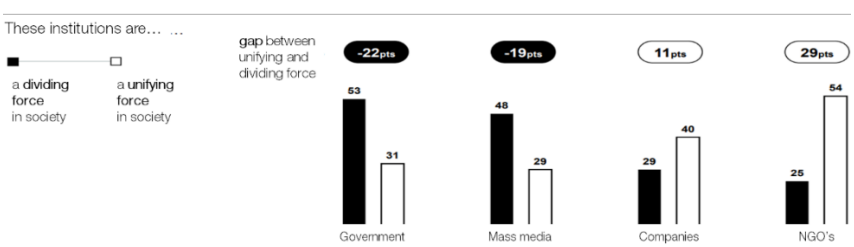
Brands play a crucial role in driving behavioral change for organizations and, more importantly, for customers. Marketers must develop a strong value proposition in order to meet the demands of their target audiences. Empirical studies validate that having a relevant purpose is a fundamental lever for companies when it comes to regaining trust, and achieving a stronger bond with their stakeholders. Recent studies have shown, for example, that the commitment of companies with a clear sense of purpose improved performance in their income statements, as well as in the impact for the common good of their target audiences. Without an authentic and coherent purpose it is not possible to generate trust, and without this it is not possible to achieve a good reputation. Hence, defining a solid and shared purpose is the first step in any organizational project.

Now that we have understood the need to create healthy and solid brands, we are going to review what brands should communicate, how they should do it and to whom they should be directed. Before designing a brand purpose, it is necessary to be very clear about what product or service the company is offering, for what consumer archetype, and what specific values the brand is being given. Archetypes are a way to understand and describe the motivations

of customers as a group, and answer questions like what are their goals? o What drives their decisions? The archetypes are fully complementary to the description of the sociodemographic target, and help to deepen and better understand their desires, concerns and vital motivations.

One of the first issues that should be reviewed is whether brands use their channels solely to sell their goods and services, or if they additionally have an ethical commitment to the world or society. In any case, it is an individual choice, but it is a fact that consumers declare that they increasingly favor brands that identify with a cause. And going further, faced with disillusionment with institutions, more and more consumers are giving companies active responsibility for social change. The purpose refers to the identity of the organization, its DNA and reason for being, and must be understood as the pillar of the strategy and the reference framework for decision-making and actions of all company employees.

Defining the purpose is key and it is not easy, especially if you are looking to achieve consistency and a real impact in the organization. It is a process of dynamic dialogue and in constant construction between the different interest groups, both internal and external. The main proof that you have a purpose that generates a positive and beneficial impact for others, that is, its quality, has three fundamental areas: coherence, authenticity, and integrity. The measurement of the purpose, if the strategic role is a generator of transformation, trust, reputation, differentiation and even attracting investment or talent, has been demonstrated in practice, so the challenge lies in advancing in its management, activation and implementation.



Source: Edelmann Barometer. 2022

Figure 3. The government and the media are considered dividers (% that affirms it).

Likewise, they require brands to act consistently, and to materialize their purposes or social causes, capable of offering a benefit or value to their target audience, having a positive impact on their lives. Purposeful brands are those that distinguish their value proposition in their communication, precisely

because it is part of their business culture. Brands seek to connect with their target audiences through these shared values, in addition to their mission and vision, or what is the same, their corporate culture. Do not confuse the brand purpose with business objectives, strategies and challenges. Applying the brand purpose system generates personal and solid relationships with the consumer, which supports the resilience of brands, making a better impact in times of crisis.

Thus, before starting a branding process, some aspects must be taken into account:

1. Business scope: This aspect specifies the area of action, beyond the product, for which it is supposed to be useful for the service for which it has been created.
2. The unique way of doing things: How we bring our business to life, what are the differentiating attributes, and what makes the company unique compared to other brands that operate in our business area.
3. Why and what for: This is where the brand thinks beyond its functional use, to focus on how it can help society from its position.

The author of the so-called "Golden Circle" inverts the thought process, inviting us to put first what we do it for. This model defines and describes the degree of strength of the purpose, and discovers the most relevant levers to strengthen it. The model is made up of a series of management levers, and requires the action of several areas:

1. Clear, defined, shared and concrete strategy.
2. Distributed leadership among teams and departmental areas, all having an extra role in commitment and involvement, and working as a horizontal and transversal model in skills and functions.
3. Management systems and processes between departments: They must be clearly defined with the higher business units, and where they flow up and down for the same common goal.
4. Communication that impacts the generation of favourable behaviours by employees: commitment, proactivity, and behaviours to add to the role that each worker already has, as well as their sense of unity. In addition, it has a series of facilitators for its implementation, such as the promotion of work environments based on values, trust, motivation, as well as certain individual characteristics of the employees themselves (personal purpose).

But the key part of the model is the one that explains the state of the activation and implementation process, which consists of the generation of a shared purpose in the organization, authentic, coherent and complete. And to generate that shared sense, the model emphasizes 3 dimensions:

- The level of knowledge: Which consists of explaining, disseminating, and deploying the purpose so that it reaches the day to day of each department, team and person in the organization. In short, let employees know you.
- The value of internalization: That generates the connection of the purpose of the organization with the personal values of each one of the employees. For these to identify with it, it is essential that each one of them develop the strategy in their role and departmental function, and transversally with the rest of the areas.
- The degree of contribution: Which is that the purpose is reflected in the day-to-day systematizations. That employees see their daily and habitual work as a contribution to the development of the company's global purpose, and in turn of the multidisciplinary teams responding to the same objective of effectiveness and efficiency, a process that involves the entire organization, and that must lead the CEO through a corporate culture that permeates to all areas.

And from these 3 dimensions of the management model, knowledge, contribution and internalization, the purpose strength indicator is extracted, the Purpose Strength Index, which offers us a global metric to evaluate the degree of health of the purpose in organizations, based on to the balance and intensity of these dimensions, and that allows us to give a value to its implementation on a maximum of points. One of the most revealing data has been discovering that when the purpose is implemented consistently, that is, in a balanced way in its three dimensions, the impact it has on individual commitment, extra behaviors in roles and collective unity multiply. until it is more than double.

It is therefore key that in the design of action plans to activate and implement the purpose in an organization, work is done in unison on these three dimensions, in order to achieve high levels of consistency in implementation, in balance and intensity., and be able to unfold the full potential contained in the corporate purpose. Organizations that understand its strategic importance will make a difference, since they will understand its transformative force to align the entire organization around the same direction,

which gives them coherence, authenticity and cohesion, and which nourishes the strategy, defines the culture, impacts in the organizational model, and is expressed and experienced at all points of contact and experiences with the organization.

The 'Purpose Strength Index' is presented, the first indicator to activate and measure the corporate purpose. The corporate purpose must be understood as the foundation of the strategy, that which explains why what is done is done, and which establishes the frame of reference that will guide all the actions and decisions of the organization. In recent years we have discovered its strategic role as a source of transformation, generation of trust and differentiation" (Losana and Fontán, 2021).

1. Leadership and fluid communication between departments are the variables on which the organization can act more directly.
2. The levers to take care of our leadership and management systems.
3. The implementation of the purpose raises the behaviours of involvement and commitment in the roles of the workers.
4. Sharing the purpose of the company ensures the individual commitment of employees, as well as teamwork among the people who form it.
5. The strategy is the main lever in the implementation of the purpose, which must guide and mark the goal of what must be achieved, on the business, crucial to enhance the meaning and contribution of networking and daily work.
6. Trust notably conditions the impact that leadership, management systems, communication and collaboration have on the generation of a shared meaning.
7. Relational and contribution values are great facilitators of purpose.
8. The larger the organization, the more important it becomes to align personnel policies with purpose.
9. Without purpose there is no commitment: Operating or not under the purpose model is an individual option that each company must adopt, but it is true that it is a fact that consumers declare to empathize more with brands that identify their work with a legitimate cause.
10. Consistency in the implementation of the purpose more than doubles the development of behaviours of involvement and commitment to the brand and the company, both by employees and by customers. In such a critical social moment, the responsibility, both individual and of large companies, is vital to achieve a better environment to

generate progress. For this, conscientious people are needed, as well as information and awareness messages for citizens who lead and champion causes with an effective social impact.

This is why the purpose must be ambitious and consistent, acting as the compass direction for a brand. It is of transcendental importance, and all its assets are aligned to bring that purpose to life, from brand strategy, communication with the consumer (ATL and BTL, Public Relations, POS material, consumer experience... .), innovation, internal communication with employees or actions with suppliers.

In environments such as the current one, characterized by disruption and historical change, carrying out all of the above is particularly complex. The volatility, uncertainty, complexity and ambiguity present in the market lead to a certain demand in a transversal way, which is especially evident in areas such as Digital Marketing. Regarding the context, it can be said that the market, especially in the digital field, is horizontal, without borders. Brands are faced with the need to adopt a "global" position, thinking in global terms, but acting locally at the same time, often placing different social and legal frameworks, which require a special effort to adapt.

Source: Own elaboration

Figure 4. The truth of the reputation.

- Ability to influence: Make ideas, the vision of the company, a reality, within matrix structures that are increasingly complex and changing, but more dynamic.
- Dialogue and negotiation with interest groups and generation of traction.
- Social impact: Conceiving the company as a group of people, which requires leadership for its internal development, and to generate external benefit.
- Capacity for synthesis and focus: Move quickly, making others move in the same direction, executing with speed only what is relevant.

- Entrepreneurial attitude: Looking for the way, tools, and resources to achieve business goals in a creative and autonomous way.
- Ability to adopt tactical approaches: When circumstances require it and without giving up the long-term strategic vision, analysing indicators and adjusting deviations.
- Finally, it cannot be ignored that, from the point of view of their level of development or evolution as a person, the public is not homogeneous, but plural and changing. For any marketing professional, these words sound like a challenge, since it is the brands that must aspire to the values of consumers, instead of being the consumers who aspire to the values of brands.

Table 1 shows the digital transformation of digital marketing from the incomplete transformation to the complete transformation, taking into account the focus, the objective, the digital strategy, the participation of the CEO, the areas involved, the type of innovation, the management of the change and talent, as well as culture.

In the 90s, marketing began an evolution mainly due to technological advances. A greater focus can be identified on additional customer service, on the relationship with it, and on the level of knowledge of its target audiences. In recent years, through reading the data that the client himself is leaving, companies are able to interpret and design additional strategies towards them, an aspect in which brands with a purpose can work to generate closer relationships with your clients.

In recent years, corporate purpose has become much more than a trend in the world of management: the Davos manifesto or the heyday of liberalism for stakeholders is proof of this. Different authors defend the need for organizations to specify and activate their purpose to inspire confidence in the market, and therefore gain social legitimacy that enables them to continue operating. Society demands that companies think both about the economic value they generate, and about generating an ethical, social and environmental impact, which contributes to the improvement and sustainability of the environment in which they carry out their activity.

One of the most decisive and efficient business aspects to achieve a link with all interest groups is to have a relevant, true and full purpose, on which to base the identity of the companies. In this context, the purpose emerges as a basic resource to generate competitiveness, long-term differentiation, as well as to obtain the trust of all the public that make up the company, giving the organization social legitimacy to operate.

Table 1. Digital transformation in marketing

	Incomplete Transformation	Complete Transformation
Centre of Attention	Organization activity.	Organization activity.
Objectives	Cost savings, increased sales, and productivity. Short termism.	New business model. Opportunities and threats of disruption.
Digital Strategy	Does not exist.	Defined and communicated.
CEO Involvement	Delegates to relevant areas.	Transformation leader.
Involved Areas	CMO and CXO.	All.
Type of Innovation	Technology and incremental innovation.	Disturbing.
Change Management	Sporadic in some projects/areas.	Concerted action at all levels.
Talent Management	Develop digital skills.	Manage diversity. Collaborative and innovative skills, without fear of taking risks. Attract talent.
Culture	Silo culture.	Culture of innovation. Change in the company culture towards greater emotional intelligence.

Source: Own elaboration

The digital environment generates flexible contact points that allow interaction with the consumer, establishing two-way relationships, such as conversation or interaction. Another advantage is that, aligned with the general objectives of the campaigns, it allows the generation of communication synergies with other contact points, directing traffic to richer pieces such as ads or videos on social networks. Programmatic advertising, together with branded content, are other examples of how purpose and technology can come together to achieve effectiveness and efficiency in communication plans. Although they provide less coverage and top of mind than other traditional media (OOH, print, TV), they allow segmenting and reaching target audiences where the key conversations related to our purpose occur, thus generating more lasting and intimate relationships. Network analysis and digital listening also make it possible to select brand ambassadors, or Influencers, who will be able to establish conversation trends by uniting the brand and opinion generators, significantly strengthening the brand's communication strategy through of this segmentation. They also allow learning, feedback and strengthening the strategy, in addition to evolving the purpose to maintain relevance in the mind of the consumer.

From a business point of view, brands with a purpose are more resilient and better withstand the external onslaught of crises or pandemics, for

example, and internal ones such as the loss of competitiveness, since they generate stronger and more lasting relationships with their consumers.

Results

The results of this research are a fundamental part of it, as they help and provide validity and consistency to the main objectives and in order to validate them. The main findings of this study enable us to explore the role of Digitalization as a strategic driver in cross-functional coordination among key performance teams in a key performance teams in a company, and how purposeful marketing, working across aligned purpose, working across aligned departments generates good results with its customers. The presentation of the qualitative data is collected in the tables throughout the text interpretation of these indicators is obtained from in-depth interviews of the chosen sample of senior managers, in addition previous scientific literature supporting the work has been reviewed.

Conclusion

Today, reinventing and redefining business models that are sustainable in the long term in organizations, involves acquiring a new critical organizational attitude and a holistic organizations, involves acquiring a new critical organizational attitude and a holistic view of corporate culture that permeates the entire organization and extends organizational work models with flexible roles and functions throughout the organization, as possessing a strategic vision to solve operationally the challenges that operationally solve the challenges of moving forward, overcoming difficulties and evolving.

In recent years, digital transformation and technology have been the main focus of the general sectors and specifically the business model of large organizations and it has been considered a strategic factor to know how to implement it among the teams of key areas in companies, in order to evolve towards sustainable models. Brands have reinvented themselves toward more sustainable and people-centered environments, with a clear, true and relevant purpose, which is born from the corporate culture, downwards and permeates the entire organization, and in order for it to be reasonable over time, it must be responsible for society and the global common good. We are part of the era

of purpose for people, and to this end, teams have to work in a multidisciplinary way, with clear competencies and well-defined roles. It is crucial, therefore, that company leaders work in a clear way on the guidelines to follow in order to work efficiently and effectively, ultimately with effectiveness and generating solutions in a clear way.

We define them as the following:

- Analyze a complete sector, its business model, from the corporate culture and purpose worked by crucial functional areas within the organization in setting common objectives by areas in the different departments of key performance resources in the company and how to work the purpose, to land it in the final service to the customer.
- To describe from the general management the organizational culture, towards the middle management and from these the most operative departments, with the main to define roles and function impregnating in all the departments until its achievement to the final customer achievement.
- To design a sufficiently representative sample both in quality of the interviewees and in the number of interviews carried out.
- To establish some hypotheses of departure or premises which are these same objectives and to try to obtain some conclusions and results that help to understand the raised objectives.

References

Aaker, D. A. (2009). *Managing brand equity*. simon and schuster.

Ancarani, A., and Di Mauro, C. (). How does digitization affect the behavior of purchasers and team members in related functions? *Digitalisierung im Einkauf* (pp. 11-26). Springer Gabler, Wiesbaden.

Ayestaran, R. (2021). Customer Relationship Marketing (CRM) for the Design of Strategies in Digital Marketing. In *Environment and Innovation Strategies to Promote Growth and Sustainability* (pp. 108-119). CRC Press.

Bae, J., and Lawler, J. J. (2000). Organizational and HRM strategies in Korea, Impact on firm performance in an emerging economy. *Academy of management journal.*

Bendak, S., Shikhli, A. M., and Abdel-Razek, R. H. (2020). How changing organizational culture can enhance innovation: Development of the innovative culture enhancement framework. *Cogent Business & Management*, 7(1), 1712125.

Bican, P., and Brem, A. (2020). Digital Business Model, Digital Transformation, Digital Entrepreneurship, Is There A Sustainable "Digital"? *MDPI journal, Sustainability* 2020, 12, 5239, doi:10.3390/su12135239.

Bock, L. (2015). *The new formula of work*. Ed. Connect.

Brexendorf, T. O., Bayus, B., and Keller, K. L. (2015). Understanding the interplay between brand and innovation management: findings and future research directions. *Journal of the Academy of Marketing Science*, 43(5), 548-557.

Desmet, D., Duncan, E., Scanlan, J., and Singer, M., (2015). *Six building blocks for creating a high-performing digital enterprise*. McKinsey & Company.

Dorner, K., and Meffert, J. (2015). *Nine questions to help you get your digital transformation right*. McKinsey & Company.

Fontán, C., Losana, A. A., Guzmán-Araña, S., and Gallego, S. (2021). 10 learnings for the future of business management. *Harvard Deusto business review*, (315), 20-27.

Gallardo-Gallardo, E., Thunnissen, M., and Scullion, H. (2017). Special issue of International Journal of Human Resource Management. A contextualized approach to Talent Management, Advancing the field. *The international journal of human resources management.*

He, Q., Guaita-Martínez, J. M., and Botella-Carrubi, D. (2020). How brand equity affects firm productivity, The role of R&D and human capital. *Economic research-Ekonomska istraživanja*, 33(1), 2976-2992.

Kane, G. C., et al. (2015). *Is Your Business Ready for a Digital Future?* MIT.

Kartajaya, H., Setiawan, I., and Kotler, P. (2021). Marketing 5.0, *Technology for humanity*. John Wiley & Sons.

Kleinaltenkamp, M., Brodie, R. J., Frow, P., Hughes, T., Peters, L. D., and Woratschek, H. (2012). *Resource integration. Marketing Theory*, 12(2), 201-205.

Kohnke, O. (2017). *It's Not Just About Technology, The People Side of Digitization. Shaping the Digital Enterprise* (pp. 69-91). Springer International Publishing.

Kotarbe, M. (2018). Digital transformation of business models. *Foundations of Management*, Vol. 10.

Kotler, P., Kartajaya, H., and Setiawan, I. (2017). Marketing 4.0, *der Leitfaden für das Marketing der Zukunft*. Campus Verlag [*the guide for the marketing of the future*. Campus Publisher].

Lombardo, J. L. (2015). *Problems and challenges of business management in the digital economy, comparative and systemic study of management skills*. Thesis, Camilo José Cela University.

Martínez, J. M. G., Puertas, R., Martín, J. M. M., and Ribeiro-Soriano, D. (2022). Digitalization, innovation and environmental policies aimed at achieving sustainable production. *Sustainable Production and Consumption*, 32, 92-100.

Montero Guerra, J. M. (2021). *The impact of digital transformation on talent management*.

Quintana, M. (2015). From human resources to people management, a new vision of talent in the digital age. *Communication Papers magazine*, No. 8 (Monographic II), pages 64 to 66.

Roig, C. (2017). Industry 4.0, *the fourth industrial (re) evolution*. Harvard

Ruiz-Alba, J. L., Guesalaga, R., Ayestarán, R., and Mediano, J. M. (2019). Interfunctional coordination: therole of digitization. *Journal of Business & Industrial Marketing.*

Scwap, K. (2017). *What is the fourth industrial revolution? How will it define our future?* Ed. Debate.

Sinek, S. (2019). *Cómo los grandes líderes te motivan a actuar* [*How great leaders motivate you to act*].

Tajeddini, K., Altinay, L., and Ratten, V. (2017). Service innovativeness and the structuring of organizations, The moderating roles of learning orientation and inter-functional coordination. *International Journal of Hospitality Management*, 65, 100-114.

Wade, M., and Marchant, D. (2014). Are you prepared for your digital transformation? Understanding the power of AMPS technology in organizational change. *Tomorrow's challenges*. IMD Lausanne, Switzerland

Wall, S., and Lepsinger, R. (1994). *Cross-functional obstacles*. Training May, 125-126.

Wang, G., Gunasekaran, A., Ngai, E. W., and Papadopoulos, T. (2016). Big data analytics in logistics and supply chain management, Certain investigations for research and applications. *International Journal of Production Economics*, 176, 98-110.

Yoo, Y. et al., (2012). Organizing for Innovation in the Digitized World. *Organization Science*, 23(5), pp. 1398–1408.

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