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Analysis of Portugal's macroenvironment in the view of Digital Transformation of SMEs using the PESTE Framework –

Exploration of Political Factors

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Abstract

The digital Transformation has revolutionized entire sectors in recent years. Yet, SMEs struggle to successfully implement such profound organizational transformation and thus jeopardize their competitiveness in the long term. Scholars study internal, company-related factors almost exclusively, whereas external factors are only sparsely considered. Therefore, this thesis applies the PESTE-framework to investigate external factors affecting the digital transformation of Portuguese SMEs. This section explores political aspects in Portugal, comparing them to Italy and Israel and analyzing possible influence on SMEs' digital transformation. Based on these findings, recommendations were developed, including interdisciplinary data collection processes, innovation hubs, tailored trainings, and trust seals.

Keywords: Digital Transformation, SMEs, External Factors, PESTE-Analysis, Portugal, Political Factors

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1 Introduction

Digital transformation (DT) – hardly a sector that is not concerned with this topic. From researchers and businesses to legislators and the European Commission, everyone around the globe is placing DT at the top of their agenda and making it a priority. Not surprising, given that DT has affected all dimensions of the organization of economic, public, and social activities by simplifying the modalities of communication, increasing the value of technology, and changing the economic value of distance. This leads to an extensive literature on DT, European Union (EU) programs to support DT, new roles within companies such as the Chief Information Officer, and entire changing industries. This has been accelerated by the advent of advanced technologies and has ushered in a new era of global digital development. The widespread use of digital information and communication solutions fundamentally changes business life and restructures economic relationships. Digital disruption is ever-present, and many organizations worldwide are actively pursuing DT. This has become a necessity rather than a small item on the strategic plan for the next few years, especially in the wake of the Covid-19 crisis. Due to social distancing and global lockdowns, companies were forced to digitalize their processes. This has a pervasive impact on all industries and business sectors, as Digitalization opens up a whole new world of opportunities and challenges (Schallmo and Williams 2018; Kumar et al. 2021; Rowles and Brown 2017).

In the perspective of enterprises, DT is the transition process related to adopting digital technology in every aspect of business and enabling companies to create new products and services and develop new ways of running a business more efficiently. It concerns the shift digital technologies cause for partial or entire segments within an organization or complete business models within a specific industry. While many companies avidly adopt the new developments to strengthen their competitive advantage, others face digitalization obstacles and are forced to change their business processes. The latter is especially true for Small and Medium

Enterprises (SME). Whereby particularly for SMEs, driving forward the DT is crucial to remain competitive in the long term and to be able to satisfy the ever-changing demand of the customer. That applies specifically to the next generation of digital natives, the first generation that has grown up with mobile phones and the internet from birth. These Digital technologies are established as part of society's daily routine and changed the way of communicating, consume and creating - today, one-third of all retail is done online, compared to only 1 percent in 2000. However, customer and digital natives' needs go far beyond an online shop or a simple website (Schallmo and Williams 2018; Kumar et al. 2021; Rowles and Brown 2017).

The importance of the DT is not just reflected by its precise contribution to strengthening and accelerating the dynamics of economic activity, rather by its role in the sustainable growth of the economy as a collective phenomenon. In this respect, SMEs also contribute significantly and represent a significant pillar of the European economy. They hold around 17.00% of all patents in Europe, therefore contributing to economic growth and innovation, and substantial job creation. This also holds for Portugal's economy, representing 76.00% of all enterprises in Portugal and contributing to 68.30% of value-added and 77.40% employees (European Commission 2019). These numbers are well above the EU average and manifest in the landscape of Portugal's micro-businesses. Given their importance to the economy, it is in the interest of many stakeholders that SMEs in Portugal join the DT trajectory to be part of a new digital economy (Devezas, Leitão, and Sarygulov 2021).

Yet, Portuguese SMEs are still lagging in the DT and are among the countries where 40% of SMEs are not even equipped with a computer (OECD 2021d). For this reason, many private and public stakeholders have addressed the challenges and problems, resulting in frameworks, guidelines, and programs to support SMEs. Many blame internal factors like the lack of digital strategy and mindset, which has led to the development of tools to check "digital readiness" or the own "digital maturity". These frameworks and tools have been around for a few years,

which raises the question of why the step towards digitalization is still such a hurdle and why some EU countries have successfully mastered the DT and others not. Does Portugal provide a weaker starting point for DT than other countries? Are the frontier countries providing other foundations Portugal could adapt to?

Due to these reasons and the identified research gap, this thesis explores Portugal's macroenvironment, more precisely Portugal's Political, Economic, Social, Technological, and Environmental, and if those factors represent a solid foundation for SMEs to transform digitally. To research the topic, the thesis outline is presented in Figure 1.

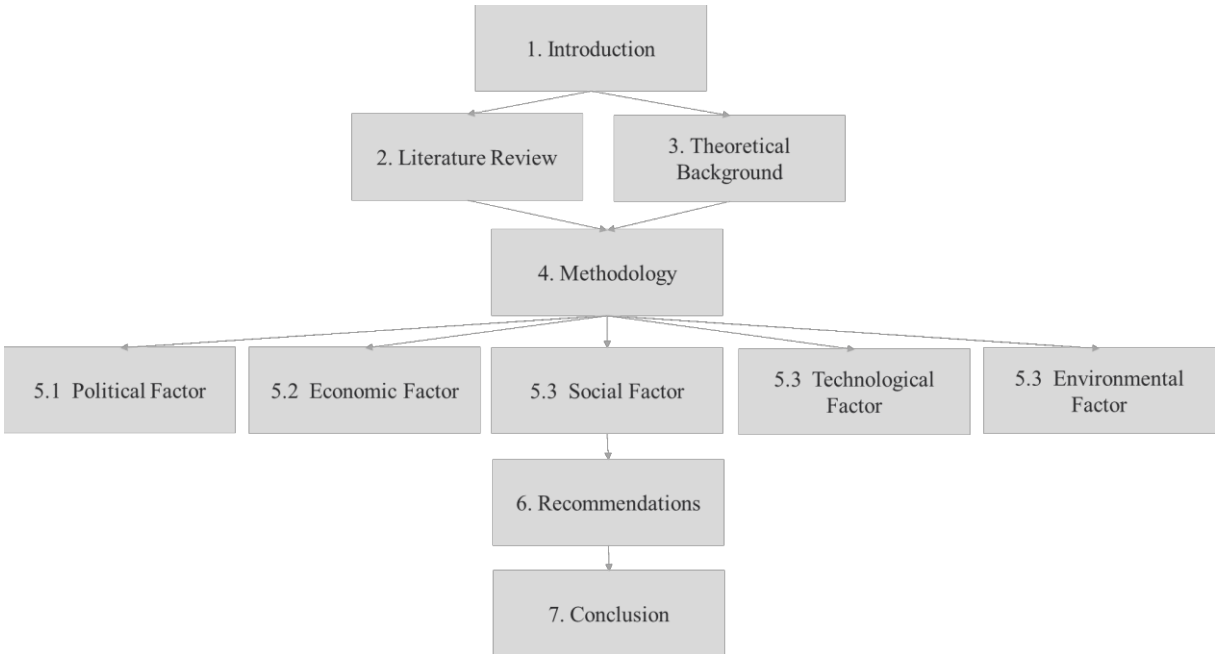


Figure 1: Thesis Outline (Source: own illustration)

The thesis begins with a Literature Review that summarises various theories and frameworks in the context of DT and its factors. After that, the Theoretical Background for the further course of the thesis is presented. This mainly concerns the State of Knowledge of DT, including an explanation and delimitation of digitalization, digitalization, and DT. This is followed by an analysis about Portugal and SMEs, followed by the correlation between SMEs and Portugal in terms of DT. Finally, the Theoretical Background describes the PESTE framework used. In the next chapter, the Methodology used in this thesis is outlined. Including the Research Strategy,

the group follows the Data Collection and Data Analysis. Chapter five analyzes external factors using the PESTE framework applied to Portuguese SMEs. The subchapters deal with the political, economic, social, technological, and environmental factors affecting Portugal and its SMEs. Each sub-chapter deals with carefully selected dimensions to provide a deep insight into the external factors in the areas of each section of the PESTE. After outlining the external factors and analyzing the Portuguese environment, the research group formulated Recommendations addressed to both the public and private sectors to support the DT of SMEs in Portugal. In particular, four recommendations were elaborated. In addition to these, Chapter six addresses Limitations and suggestions for Future Research. Finally, the last chapter presents the Conclusion of the thesis.

2 Literature Review

Based on the researched topic of this thesis, a detailed look at the status quo of the current literature will be taken in the following section. This emphasizes the topic's relevance and contextualizes it within the current state of knowledge. Given the findings and the status of the literature, a research gap is identified and thus serves to formulate a precise research topic. The methodological procedure of the literature review is described in detail in section 4.1.

2.1 Digital Transformation

The following section aims to investigate the current state of knowledge in the light of DT of SMEs in Portugal. Extant literature was reviewed to define the critical areas of DT and identify the dimensions for SMEs. Furthermore, the notions of digitization and digitalization will be restricted from each other. Different definitions will be compared for all the terms to find overlaps. Based on the findings, a final definition will be formulated.

2.1.1 State of Knowledge

The term DT is discussed in several studies and papers, and the term is gaining in importance. Savić (2020) states in her study that there is currently no single and commonly accepted definition of the term. DT offers valuable opportunities for businesses, especially SMEs; therefore, clarifying and conceptualizing the term is crucial (Savić 2020). The following Table illustrates that researchers, scientists, and business experts agree on many aspects of the dimensions of DT.

Study	Dimension
Schallmo and Williams (2018, 6–7)	"[…] digital transformation requires individuals to rethink old processes and reimagine new processes and decisions. […] Digital transformation needs to be an integrated and continuous part of any overall business strategy."
Agrifoglio et al. (2020, 4)	"[…] digital transformation is changing business models and organizational culture. It has an impact on its functioning, its organization, its teams, but more generally on its governance."
F. Matos et al. (2020, 9)	"Digital Transformation (DT) refers to the process of introduction and use of digital technology in all domains of human activity, where that makes sense, from the scientific, economic, and computational points of view. This embraces almost all human activities."

Table 1: Dimensions of Digital Transformation (Source: own illustration)

Much of the current literature on DT pays particular attention to the change in organizational culture and the impact on the employee's mindset. Matos et al. (2020) highlight the impact on all domains of human activity. Latter results in a change in the organizational culture described by Agrifoglio et al. (2020) and are underlined by Schallmo and Williams (2018). All individuals within the company have to rethink old processes, resulting in a change of mindset. Organizational culture is mainly determined by how a business is governed. Hence, the management must implement DT as a continuous part of the overall strategy and vision (Schallmo and Williams 2018), affecting employees and culture. DT is not limited to a standalone implementation of a technological tool. The latter is also supported by the study conducted by Savić (2020), where digital technologies are the basis and enablers of DT, but DT is seen as an entire end-to-end process. DT, therefore, has a greater significance for the companies as a whole. Based on the review, the following definition is formulated:

In this work, DT is defined as the reimagination of business models and processes via the use of data and technology accompanied by an alignment of culture and governance on an individual and, at the same time, organizational level.

2.1.2 Digitization vs. Digitalization

For an overall understanding of the dimension of DT, the familiar concepts of digitization and digitalization must be distinguished. This thesis will use both terms "digitization" and "digitalization". Indeed, it is undeniable that both terms are related, yet they imply different things (Gbadegeshin 2019). Therefore, the differentiation between these terms is valuable to see the whole picture of DT and take a strategic and organizational decision. The existing literature on the differentiation is extensive and shows a great range of different studies discussing both terms. Due to the incredible diversity, three representative definitions were selected for each term.

2.1.2.1 Digitization

Study	Dimension
Schallmo and Williams (2018, 5)	"Researchers across different fields would define digitization as the transformation of some type of analog or physical artifact into a digital artifact."
Legner et al. (2017, 301)	"Digitization dematerializes information and decouples information from physical carriers and storage, transmission, and processing equipment."
Gbadegeshin (2019, 50)	"[…] digitization is a conversion of analog information into digital forms."

Table 2: Dimensions of Digitization (Source: own illustration)

To date, several studies suggest that the term "digitization" mainly describes the process of converting analog information to digital. Both Schallmo and Williams (2018) and Gbadegeshin (2019) refer to this conversion, and Legner et al. (2017) describe this straightforward process as more detailed. Yet, the outcome is very comparable, as the dematerialization of information can be seen as a transformation from analog to digital. Technically it means, that analog information (e.g., pages, documents, etc.) is turned into bytes (e.g., by scanning a document, replacing hand-filled surveys with online versions). The available literature seems to agree with the definition of "digitization uniformly".

In this work, "digitization" will be described as the dematerialization of information from analog to digital.

2.1.2.2 Digitalization

Study	Dimension
i-SCOOP (2021)	"Digitalization means the use of digital technologies and data (digitized and natively digital) in order to create revenue, improve business, replace/transform business processes (not simply digitizing them) and create an environment for digital business, whereby digital information is at the core."
Legner et al. (2017, 301)	"[…] digitalization has been coined to describe the manifold sociotechnical phenomena and processes of adopting and using these technologies in broader individual, organizational, and societal contexts."
Gbadegeshin (2019, 50)	"Scholarly, digitalization is a structuring of […] technologies across: infrastructural, terminal, […] process, organization, business domain, industries, and the entire economy and society levels."

Table 3: Dimensions of Digitalization (Source: own illustration)

The literature review made clear that "digitalization" has a broader impact on a company as a whole. Cross-sectional studies point to the fact that "digitalization" has not only a technical character. (Legner et al.) (2017) emphasized that "digitalization" impacts the entire organization and also influences at an individual level. Hence, the term refers to creating and harvesting value in new ways (e.g., use of technology and digitized information). When analyzing all three definitions, "digitalization" implies a change in the business itself and may disrupt fundamental business strategies (Gobble 2018). Latter is highlighted by i-SCOOP (2021), as digitalization is about transforming information from analog to digital and changing

business processes and how business is done. All three definitions emphasize the use and the structuring of technologies, underlining that digitalization also has a strategic character for businesses, as processes may have to be adjusted.

In this work, "digitalization" uses and structures technologies and digitized information to change business processes, lower costs, and create new value. "Digitalization" therefore implies for organizations the existence of adequate infrastructure.

2.1.3 Factors influencing the DT of SMEs

Having conceptualized the notion of DT, the following section analyzes which factors influence SMEs' DT according to current literature. The systematic search in the light of SMEs' DT made apparent that most of the studies were released in the recent past and clearly show that the DT of SMEs is an emerging topic, which is increasingly gaining in importance. The studies described in Table 4 primarily do not refer to a specific country but have a general approach. Stich et al. (2020) investigate organizational capabilities within the sphere of SMEs in Germany, while Zhen et al. (2021) elaborate on the digital culture of SMEs in Pakistan. Scuotto et al. (2021) examine a sample of 2,156,360 European SMEs to analyze the digital capacities on an individual level.

Last but not least, Matarazzo et al. (2021) deal with Italian SMEs, whereas the OECD (2021d) study focuses on its member states. Only two studies could be found in the detailed search for DT of Portuguese SMEs, which referred to larger companies. The study by Porfírio et al. (2021) should be mentioned here, which deals with the DT of Portuguese companies but focuses exclusively on the leadership characteristics, which must vary from company to company in order to drive a DT. Pereira et al. (2019) shed light on the state of the art of Portuguese organizations in the context of DT. (2021) should be mentioned here, dealing with the DT of Portuguese companies but focusing exclusively on leadership characteristics, which must vary from company to company in order to drive a DT. Pereira et al. (2019) shed light on the state

of the art of Portuguese organizations in the context of DT. Although the study covers Portuguese companies of all sizes, the authors accentuate that only two papers deal with the DT of SMEs in Portugal. However, these studies refer to the tourism sector. Hence, the authors emphasize in their conclusion that no relevant studies are available for the DT of Portuguese SMEs, justifying the topic's relevance.

Study	Dimensions
Pelletier and Cloutier (2019b)	Perceptions of IT issues; challenges of financing DT of SMEs
Cenamor, Parida, and Wincent (2019)	Digital platform capability influencing financial performance of SMEs; the necessity of digital capabilities to adopt and implement technologies
Pelletier and Cloutier (2019a)	Challenges of DT in SMEs; social dimensions at the individual level; economic and political inertia at the systemic level; investments in strategic, intellectual, structural, formal and informal, social and cultural dimensions
Ulas (2019)	Factors affecting SME's DT processes; redesigning the organizational business; lack of knowledge when adapting technologies; government interventions and providence of incentives
Kääriäinen et al. (2020)	Digital maturity and DT models for SMEs; rethinking current operations and business models; DT affecting culture, processes, staff, and business models
Stich et al. (2020)	Investigating cultural and organizational aspects of DT in SMEs; Holistic view of DT exceeding technical aspects

Isensee et al. (2020)	SME's digital development through organizational culture development; external factors including training and industry characteristics
Zhen et al. (2021)	Developing a model for DT based on organizational culture and readiness and digital capabilities; the relationship between digital culture and innovation within SMEs
Scuotto et al. (2021)	Relevance of individual digital capabilities for SMEs' growth; the need for internal/individual digital capabilities
Matarazzo et al. (2021)	Investigating dynamic capabilities fostering the DT of SMEs in Italy; relevance of learning capabilities for DT; organizational capabilities
(OECD 2021d)	Challenges of SMEs' DT; emphasizing the sector-specific differences for DT; financing and infrastructure gap; governments boosting SMEs' DT
Troise et al. (2021)	Investigating the digital and innovational capabilities of SMEs; Improving organizational agility through technology; adapting to changing external conditions

Table 4: Factors influencing the DT of SMEs (Source: own illustration)

Some of the studies described above mention external factors that may influence the DT of SMEs but do not elaborate on them. For example, the study by Isensee et al. (2020) notes external factors but focuses the entire research on the development of the organization and the company's culture. The external factors, such as training and industry characteristics that the study briefly mentions, are only taken as a starting point for developing internal capabilities. The OECD (2021d) cites the government as an external factor that can drive the DT of SMEs. Yet, the OECD emphasizes governmental measures strengthening the internal capacities of

SMEs, namely encouraging training and building a data culture. Further, the report elaborates on creating a suitable business environment to foster the DT of SMEs, which includes supportive regulatory frameworks and consultative instances promoting responsible digitalization policies. Troise et al. (2021) takes the constantly changing external factors as a basis for explaining the importance of internal capacities but does not describe these external factors in detail and how they could impact the company. Therefore, the study solely aims to determine how digital technologies are associated with an organization's agility. Thus, the focus is on the internal agility of the organization rather than on the influence of external factors on the DT of the companies. Furthermore, the external factors addressed by Pelletier and Cloutier (2019a) only relate to the strategic orientation of the entire organization. The report elaborates on creating a suitable business environment to foster the DT of SMEs, which includes supportive regulatory frameworks and consultative instances promoting responsible digitalization policies. Troise et al. (2021) takes the constantly changing external factors as a basis for explaining the importance of internal capacities but does not describe these external factors in detail. Therefore, the study solely aims to determine how digital technologies are associated with an organization's agility. Thus, the focus is on the internal agility of the organization rather than on the influence of external factors on the DT of the companies. Additionally, external factors addressed by Pelletier and Cloutier (2019a) only relate to the strategic orientation of the entire organization.

To conclude, the influence of internal factors is well investigated, and there are already different approaches to cover the internal challenges faced by SMEs. External factors are partially mentioned, but their importance for the DT for companies and primarily for SMEs is not evident. Therefore, this master thesis will analyze the impact of external factors of SMEs in Portugal influencing their DT. The research has also shown that, especially for Portugal, the DT of SMEs, in general, is scarcely addressed.

2.2 Frameworks

The DT of companies has become one of the main objectives in today's business world to maintain the sustainable development of enterprises. However, DT concerns all sizes and types of companies. Instruments or tools are used to help SMEs transform digitally. They come in many forms and shapes. In literature often, they are referred to as frameworks, models, roadmaps, indexes, or assessments (Zapata, Berrah, and Tabourot 2020). The word "framework" will describe all of these options for the following thesis. Many literature frameworks and guidelines support SMEs on their path through a DT (Z. Yang et al. 2021). In this section, recent literature will be reviewed to display current frameworks applied for the DT of SMEs.

One general approach was made by Deloitte (2018) in partnership with the TM Forum. They developed a digital maturity model which "evaluates digital capability across five clearly defined business dimensions to create a holistic view of digital maturity across the organization" (Christine Anderson and William Ellerby 2018). Namely, the business dimensions are Customer, Strategy, Technology, Operations, and Organization & Culture. They are divided into 28 sub-dimensions covering 179 individual criteria. According to Deloitte, the model can be used during every stage of DT – the digital maturity assessment, prioritization purposes, and the implementation process (Christine Anderson and William Ellerby 2018). Microsoft designed a roadmap to DT with a customer-centric focus. Accordingly, most companies need to "reimagine the customer experience along their value chain" by engaging with customers (Microsoft n.d.). Besides, Microsoft's roadmap includes the dimensions 'Empowering Employees', 'Optimizing Operations', and 'Transforming Products' (Microsoft n.d.). Another model was defined by Singh, Sharma, and Dhir (2021), focusing on the DT of manufacturing firms. Therefore, they created a model including six areas that a company should pay attention to when pursuing a DT. The areas are Organization Culture, Competitive

pressure, Cognitive Readiness, Organization Mindfulness, Strategic Alignments, and IT Readiness (Singh, Sharma, and Dhir 2021). For Davenport and Redman (2020), DT comes down to four key areas. Like all the models before, they look at the organization and its capability to change. Nevertheless, comparable to Deloitte, their model takes a more general approach and covers Technology, Processes, Data, and Organisational Change Capability (Thomas H. Davenport and Thomas C. Redman 2020). Blatz, Bulander, and Dietel invented another framework to measure the digital maturity level of SMEs. The three authors reviewed the current state of research and developed a maturity model covering six dimensions based on their findings. Namely, these are Company Culture and Organization, IT infrastructure, Data Maturity, Process and Operations, Product (use face), and Strategy and Leadership (Franziska Blatz, Rebecca Bulander, and Matthias Dietel 2018). Their framework covers internal areas with an additional focus on the product. Kretzschmar (2021) defines five dimensions for an SME to measure its digital maturity for a DT. He differentiates from the other frameworks making individual points for employees and organizational culture (Marion Kretzschmar 2021).

Study	**Dimensions**
(Christine Anderson and William Ellerby 2018)	Customer, Strategy, Technology, Operations, Organization & Culture
(Microsoft n.d.)	Engaging Customer, Empowering Employees, Optimizing Operations, Transforming Products
(Singh, Sharma, and Dhir 2021)	Competitive pressure, Cognitive Readiness, Organization Mindfulness, Strategic Alignments, IT Readiness
(Thomas H. Davenport and Thomas C. Redman 2020)	Technology. Processes, Data, Organizational Change Capability

(Franziska Blatz, Rebecca Bulander, and Matthias Dietel 2018)	Company Culture and Organization, IT infrastructure, Data Maturity, Process and Operations, Product (use face), Strategy and Leadership
(Marion Kretzschmar 2021)	Company Strategy, Employees, Customers, Organisational Culture, and Digital Environments

Table 5: Digital Transformation Frameworks for SMEs (Source: own illustration)

However, the displayed dimensions in Table 5 cover primarily internal aspects, and hence, the external perspective on DT for SMEs is not well covered in the literature.

2.3 Research Question

The literature provides well-founded information about the internal factors that influence SMEs to pursue a DT. Nevertheless, companies in different areas (e.g., countries, regions) might be exposed to various external factors, and those need to be considered to pursue a successful DT. The literature review of frameworks (2.2) indicates a gap in the literature for these factors. As a result, the discovered external factors are supported only by a few scientific sources. Therefore, further analysis and valence of the impact of external factors on DT should be determined in future research (Asta Taruté, 2018). Hence, this thesis investigates the macroenvironment in Portugal influencing SMEs and their DT.

3 Theoretical Background

This chapter gives an overview of the theoretical background that is indispensable for the further course of the thesis. The central four main topics of the thesis are addressed: SMEs, Portugal, and their connection to DT, as well as the applied PESTE framework.

3.1 Portugal

The following chapter represents an outline of the country of study – Portugal. Hereby, the literature review outlines a description of the country and lays down challenges the country faces in context with DT.

3.1.1 Description

As this thesis specifies on the country Portugal, this section introduces Portugal and provides information on critical factors such as political system, geography, and economy.

Portugal is one of the EU-27 member states located in the Southwest of Europe. The country is fully integrated into the EU and the Eurozone by using the Euro currency and following Brussels's European Commission directives. Along with all EU countries, Portugal's borders and ports are entirely open to free trade with other EU-27 countries. Portugal has a politically stable environment with a democratically elected parliamentary government (International Trade Administration 2021). Furthermore, Portugal is open to foreign business and investment (International Trade Administration 2021).

In terms of economic activities, wholesale and retail trade, transport, accommodation, and food services represent the most critical sectors for Portugal’s economy, accounting for 24.90%. (European Union n.d.a). The metropolitan areas of Lisbon and Norte play an essential role in the Portuguese economy as those areas generate about two-thirds of Portugal's GDP (European Union n.d.a). Further, the country’s population amounts to approximately 10.15 million people. Slightly less than half of Portugal's population lives in metropolitan regions (48.00%), compared to an OECD average of 71.00%. Conversely, a larger share of the Portuguese population lives in remote non-metro areas (15.00%) than the OECD average (8.00%) (International Trade Administration 2021; OECD 2020).

3.1.2 Challenges

As described, Portugal is part of the EU, though it represents a significant concern for the Union. It is mainly dependent on European funds and presents a lower economic growth. With the big debt crisis in 2010, growth in Portugal has slowed down (European Union 2021). Inequalities are a big issue in Portugal, reflecting at a regional level to varying constraints in terms of economic performance and future growth. Portugal's two most significant metropolitan areas (Lisbon and Norte) are not fully exploiting their potential driving force for the overall economy. Further, even though Portugal has made progress, the country still has a relatively high debt burden, limiting the governments' ability to respond to future economic shocks (OECD 2020).

Portugal is also facing challenges with long-term unemployment, slow productivity growth over the last two decades, and overall low life satisfaction among Portuguese compared with OECD standards. The country also lags behind its peers in labor force skills, although younger cohorts are much better educated than older ones. The demographic shift will soon put significant pressure on labor markets, service delivery, and public revenues, mainly outside metropolitan areas. Lastly, Portugal is facing significant demographic changes as its population has shrunk from its peak of 10,70 million in 2009 and is projected to be less than 9,00 million by 2050. Population aging will be a challenge in remote areas outside metropolitan areas, where the ratio of older people is already ten percentage points higher than in other regions of Portugal (OECD 2020).

3.2 Small and Medium-sized Enterprises

This chapter will explore Small and Medium-sized Enterprises (SMEs) by describing the term. Further, their importance for the economy, especially with regards to Portugal, will be discussed, and finally, this chapter explores the challenges SMEs face.

3.2.1 Definition

Defining SMEs is imperative in the scope of the thesis. The definition is based on the factors the EU has determined. Enterprises are categorized in micro, small, medium, or large according to three indicators: annual headcount, annual turnover, and annual total balance sheet. The EU defined a range for each category displayed in Table 6 below. This thesis focuses on SMEs. The following table only describes these three categories (European Commission 2015).

Enterprise Category	Headcount: annual work unit[1]	Annual Turnover	Annual Balance Sheet Total
Medium	<250	<= 50 million Euros	<= 43 million Euros
Small	<50	<= 10 million Euros	<= 10 million Euros
Micro	<10	<= 2 million Euros	<= 2 million Euros

Table 6: SME Definition (European Commission 2015).

3.2.2 Importance for Economy

After SMEs are defined, it is essential to outline the importance of SMEs for the economy. Since this thesis focuses on Portugal, the emphasis is placed on the Portuguese economy in the EU context.

SMEs are an essential pillar of the European economy. SMEs are a necessary contributor to economic growth and creating jobs (World Bank n.d.). In the EU-27, SMEs represent about 99.80% of all enterprises in the non-financial business sector and 65.00% of all employees as of 2020 (Patrice et al. 2021). Furthermore, 17.00% (stand:2014) of all patents in the EU are owned by SMEs, which serves as an indicator for innovation (European Union 2014).

Looking at Portugal's social and economic fabric, in 2019, SMEs in NFBS (non-financial business sector) are responsible for 68.30% of value-added and 77.40% employment. These

[1] Headcount includes: Fulltime, parttime, seasonal, and temporary headcount (excluding training, apprenticeship, parental leave, and vocational headcount). (European Commission 2016).

two indicators are approximately ten percentage points above the respective EU average for SMEs. On average, Portuguese SMEs employ 2.90 people, which corresponds to about one person less than the EU. This is reflected in the micro-enterprises landscape, accounting for a significant share in the total business population in Portugal compared to the EU, resulting in 95.40% compared to the respective EU average of 93.00%. The manufacturing and whole and retail trade sector are the most significant contributors to job creation and value-added in Portugal. Collectively, these sectors account for about half of all jobs and value-added. Annual productivity, measured as value-added per employee, amounts to EUR 22,900 (value as of 2019), resulting in slight excess of half of the EU average (European Commission 2019).

3.2.3 Challenges

After examining the importance of SMEs for the economy, this chapter focuses on challenges SMEs face in their way of operating and doing business. A low level of absorptive capacity and policy and financial constraints are the biggest challenges SMEs face (Rahman & Ramos, 2013).

The financial constraints are depicted as impeding access to funding. SMEs face more challenges in getting funding since they are seen as bearing more risk than larger enterprises. Therefore, SMEs are less attractive to investors combined with more complex access to bank loans, compromising investment and strategic development (Araújo, 2013).

Beyond that, the taxes that enterprises must pay in Portugal are high. According to the last data from the OECD, the Corporate Income Tax (CIT) paid by the Portuguese companies was higher than the European and world average. Constituting in that way is a financial constraint since the liquidity of SMEs is scarcer when compared to large enterprises, having more difficulty paying the amount of taxes required (Almeida, 2021).

In terms of policy and legal constraints, the labor legislation represents an obstacle to the growth of SMEs since the indemnity that these enterprises have to pay to fire workers is high and

complex (Araújo, 2013). Regarding capacity constraints, SMEs and their managers struggle to hire high-skilled labor. Especially specialized work with technology-related education (Fonseca, 2011).

To conclude, it is vital to consider the procedures, time, and cost required to start a business in Portugal, displayed in Table 7. It can be observed that a company can be launched fast in Portugal, yet the procedures are time-consuming, and costs are high. Therefore, bureaucracy and the costs can also be associated with Portuguese SMEs' constraints (World Bank, 2018).

Category	Portugal
Procedures (number)	6.00
Time (days)	5.00
Cost (% of income per capita)	2.10

Table 7: Starting a Business in Portugal (World Bank 2018).

Finally, it is estimated that only about 30.00-60.00% of SMEs survive more than five years. To help the EU economy, SMEs need assistance to sustain this period, and innovation is one of the critical drivers of business survival and growth (European Union n.d.b).

3.3 Digital Transformation of SMEs in Portugal

As described in the previous section, SMEs significantly impact the economy. Therefore, it is necessary to understand the factors that determine the successful implementation of the DT of SMEs. Reis et al. (2018) considered DT into three distinct elements: *"1) technological – DT based on the usage of new digital technologies such as social media, mobile, analytics or embedded devices; 2) organizational – DT demanding a modification in organizational processes or the creation of new business models; 3) social – DT is a phenomenon that is influencing all aspects of human life by, e.g., enhancing customer experience"* (J. Reis et al. 2018). Therefore, the challenges and opportunities of DT within an enterprise are located "*(1) externally, that is related to the market, (2) internally, that represents the organization and*

technical field within the company, or (3) in the core company" (Collin et al. 2015). The constraints that SMEs face have not changed over time. Carson and Cromie already reported in 1989 these three constraints: limited resources, lack of expertise, and limited impact on the market (Carson and Cromie 1989). As stated in 3.2.3, Moreno, Pinheiro, and Joia (2012) emphasized that SMEs often suffer the most due to the highly turbulent and competitive environment in which they operate (Moreno, Pinheiro, and Joia 2012). Krüger & Teuteberg (2016) identified government regulations as one of the most significant external factors affecting the company's DT process. In the context of DT, industry-related issues such as industry maturity (Nicolai Krüger and Frank Teuteberg 2016) or industry-specific needs and expectations (Biahmou Alain et al. 2016) are also significant.

It's also worth noting that financing DT is a significant barrier, particularly for SMEs, due to the costs of identifying, developing, purchasing, and integrating relevant Internet and Communication Technology (ICT) solutions that enable DT. Focusing on the information and skills necessary is a significant problem of the digital revolution, which might affect the demand for training and education to improve new professional skills and knowledge (European Commission 2016).

A study was conducted by PHC Software in partnership with Expresso to develop a guide to DT. The findings suggested that the three main challenges that managers of Portuguese SMEs face are E-commerce, Human Resources (HR) analytics, and team mobility (André de Aragão de Azevedo 2020). The World Economic Forum states that "in 2022, the digital world will contribute to 60% of the world's GDP" (World Economic Forum 2019). Within the 500 interviewed managers of Portuguese SMEs, 90.00% of them assume that DT is already underway, but most of them still need a boost for digital to be fully rooted in their business. Of these 500, enterprises state that they are less prepared for is the investment in E-commerce, with 45.00% saying they do not invest in this area and another 64.00% saying it is a challenge

they are not prepared to take on. Other challenges emerge in the management of the digital context of Portuguese SMEs, being the most prevalent the outdatedness in the face of market change (24.00%), the lack of human capital with digital knowledge (22.00%), or simply slower processes than the competitors (14.00%).

Notwithstanding these concerns, for most managers of Portuguese SMEs, long-term structural factors did not cause concern. The absence of investment in digital technology as a short-sighted error is aggravated by the lack of understanding that a DT process is not just acquiring technology (28.00% of managers assume that their digital transition is complete). It is instead a path that involves a "process in permanent dynamics, of a race against the competition […], ensuring that they are constantly questioning themselves in order to understand if they are making the most of digital" (André de Aragão de Azevedo 2020).

The previously discussed challenges such as scarcity of resources, lack of knowledge, required technology, and handling key management issues, the implementation of DT solutions for SMEs in Portugal is facing difficulties and remains limited. For this reason, external factors are assessed and represent a solid basis for combating the internal challenges.

3.4 PESTE – External Analysis

The external environment is composed of variables beyond a company's control, though these must be analyzed to adapt the business strategy to the changing business environment. Businesses operate as part of a broader ecosystem and are susceptible to several exogenous factors that can major impact a business's competitive position (Sammut-Bonnici and Galea 2015). Based on the existing literature, external factors and the business environment can be analyzed under two main areas: macro environment and industrial environment. For the macro environment, there are four well-known analytical tools: PEST, PESTEL, STEEPI, and STEEP, also called PESTE. The tools have their origin in the PEST concept, established in 1967 and written down in the “Scanning the business environment” book by Francis J. Aguilar (Çitilci

and Akbalık). The PEST method consists of four aspects: Political, Economic, Social, and Technological. The PESTEL analysis is an improved version of the PEST method, which examines two additional factors - legal and environmental. The STEEPI analysis includes social, technological, environmental, political, economic, and infrastructural elements (IEEE Computer Society 2008).

These analyses are often used in the context of strategic management decisions, as it is crucial to understand the "big picture", in which the company operates, for taking advantage of opportunities and minimizing potential risks faced by the organization (Tomayess Issa,
V. Chang, and Theodora Issa 2010). In the thesis, the PESTE framework will be applied and set in context with the DT of SMEs in Portugal. For a more detailed explanation and the framework's application method, please refer to section 4.1.

4 Methodology

The following section deals with the methodological collection of the research strategy, various data points, and the analytical approach, presenting a basis for further research.

4.1 Research Strategy

By virtue of their expertise and interest in the DT of SMEs, the authors of this thesis convened as a field lab to jointly conduct further research in this area. Hence, an in-depth study on the topic of SMEs in DT and their challenges was required.

As a first step, a Literature Review was conducted, which in general can be described as a systematic way of collecting and summarizing previous research findings. It has the advantage of creating a solid foundation for expanding knowledge and facilitating theory development. A literature review combines results and perspectives from many empirical studies. With this, the review has the power that no single study has - to provide an overview of areas where research is inconsistent and interdisciplinary. Additionally, a literature review represents an excellent tool for synthesizing research findings and highlighting areas where further research is needed

(Snyder 2019).

The literature review conducted in this thesis contains academic and professional resources related to DT and SMEs. The authors performed the literature review by using crucial keywords in different compositions for the search. The databases "Google Scholar", "Science Direct", and “Nova library search” were selected as search engines. For "Google Scholar", the search was performed with the addition “systematic review of the evidence”, in order to restrict the outcome further and to be able to find meaningful and evidence-based studies. The entire literature review was conducted in English and Portuguese. When reviewing the literature results on the databases, data cleaning was carried out at the beginning by a pure title review. Titles with the appropriate keywords and a promising short description were examined more closely. However, a significant proportion of the results were non-scientific literature or were not accessible. Scientific studies that were accessible were further investigated.

The literature review discovered that the foundation, complexity, and influences of external factors on the DT of SMEs have not yet been sufficiently researched. The absent research gave the impulse for further investigation and was made the objective of this thesis.

To achieve the objective of this thesis, to examine the macroenvironment and external factors in context with DT of SMEs, a mixed research approach of quantitative and qualitative nature was chosen as it is most appropriate in a multidisciplinary team of researchers to develop a detailed holistic understanding about the topic. Portugal was selected as the country of study, as Portugal is among the countries that lag in DT. The first temptation of the researchers was to conduct a national survey. This prove was not possible due to the limited research duration of four months, scope, and complexity of a nationwide study in the context of local SMEs. Therefore, methods and frameworks for analyzing external factors based on their benefits and limitations have been identified and carefully evaluated. They resulted in choosing the PESTE analysis to evaluate external factors. The analysis is broadly used in management and related

studies with various applications. The basic concept is to place a company, product, transaction, or any other unit of interest to be analyzed in the context of the surrounding world. Everything outside the unit of analysis is considered part of the environment (Walsh, John, PhD 2021). Following the example of two previous studies in the field of business and management, namely, "Studying Interdependencies of E-government Challenges in Tanzania along with a Pestel Analysis" (Catherine G. Mkude and Maria A. Wimmer 2015) and "Using PEST Analysis as a Tool for Refining and Focusing contexts for Information Systems Research" (Peng and Nunes 2007), this thesis applies the PESTE framework from a single country perspective. Furthermore, the framework is not applied from a single company or industry but from the perspective of a "business sector"- SMEs. (Peng and Nunes 2007; Perera 2017). The PESTE framework provides a holistic overview of a macroenvironment by observing different dimensions (Political, Economic, Social, Technological, and Environmental).

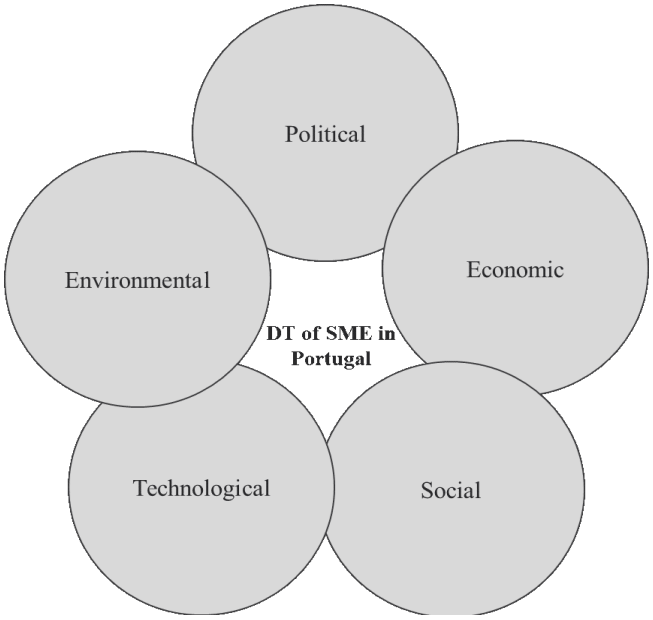


Figure 2: PESTE Factors (Source: own illustration)

After identifying the framework, cross-sectional studies were reviewed and analyzed in each dimension of the PESTE framework. Nonetheless, PESTE is far from a precise and clear-cut analytical framework. A practically infinite number of variables can evolve from each dimension. Thus, the variables that have the most significant impact on the industry, sector, or

country under study are prioritized. For all these facets of the PESTE, variables are considered, focusing on the DT of SMEs in Portugal to draw conclusions that allow narrowing down the context. A set of secondary data resources was critically reviewed, synthesized, and expanded to construct arguments and standpoints for each dimension of the PESTE analysis. Every author contributing to this thesis covers a different pre-defined factor in the PESTE framework. Due to the varying dimensions and various topics, unique best-practice and frontier countries were identified for each dimension. The researchers have chosen the frontier country in their field of study in order to compare the dimensions with the highest performer. Another criterion was that the countries somehow have comparable prospects as Portugal. Various data points and criteria have led to different countries being used for comparison. For this reason, the selection of countries used in the analysis is not coherent across the different dimensions.

Finally, the results of every dimension along the PESTE analysis were discussed in the research group in order to develop recommendations that could represent assistance for public and private institutions to support SMEs in Portugal in their DT process.

4.2 Data Collection

The following section assesses the collection process of the different data points used in this thesis. The goal is to record all necessary information about the collected and analyzed data to ensure understanding of the content and the structure of the analyzed data for further research. This thesis is based on both primary and secondary data. Finally, due to the different characteristics and data basis, various methods were chosen for the individual data collection of each dimension along with the PESTE analysis.

4.2.1 Political Factor

The first thing regarding the political factor in the PESTE analysis was defining this factor and what it includes. Furthermore, the extraction of quantitative and qualitative data was made. Due to the time and resource constraint, secondary data was preferred compared with primary data.

Reliable and updated information was found in official resources. The qualitative data were extracted from literature, reports, and articles in “Google Scholar” and “Nova library search”. The quantitative data was extracted from the European Commission, World Bank, European Central Bank (ECB), OECD, Banco de Portugal, and reliable companies’ databases.

4.2.2 Economic Factor

Various sources were used to build the final datasets for the economic factor within the scope of the PESTE analysis. A detailed definition and the sources of all data points and the three individual datasets can be found in Appendix 1. After precisely defining the economic factor within the context of DT of SMEs, meaningful data points were selected and researched. The final datasets consist of the OCED, PORDATA, and World Bank data. The data points were exported as Comma-separated values or Excel files from the databases in the first step. Yet, given the limited access to ICT-related data within the SME sphere and the fact of pointing towards the digital economy, data about the internet connection of SMEs and the usage of computers present the main DT-related variables. This approach can be stated as feasible, as the digital economy is built on basic technological innovations, such as internet connection and the usage of personal computers (Boissière 2014).

4.2.3 Social Factor

Firstly, the essential social-cultural factors influencing the DT of SMEs were selected for further investigation. Therefore, numerous sources were screened to identify the elements with the highest impact, especially in Portugal. Afterward, data points were selected, and qualitative and quantitative data from various sources were compiled. With time and length restrictions and due to the scope of the topic, professional secondary data was used additionally to primary sources. Secondly, a questionnaire was used to gather information about the age structure of SME owners in Portugal. In total, 157 participants answered the survey.

Due to the current status of this topic, many sources are dealing with the digital maturity of SMEs. However, as previously stated, most sources cover internal factors. As the social and cultural factors in using a PESTE-Analysis cover external factors, new data must be analyzed to find profound material. These were primarily gathered from the OECD, the European Commission, and government databases from Portugal and Finland.

4.2.4 Technological Factor

Firstly, several sources were used to define the technological factor and identify relevant dimensions in the context of DT of SMEs, and meaningful data points were researched and selected. Qualitative and quantitative data from different sources were collected. To have a reliable impression of the technological environment in Portugal, the collection of primary data is not feasible within the research time, capacity, and resources. However, the topic is of great interest due to its importance for the economy, which leads to many official and public institutions and private institutions and companies using their resources and researching the topic. This results in a large pool of updated professional data. Due to the enormous scope of this thesis and focusing on the SME sector within the perspective of a country, professional secondary data resources from official resources and companies represent a more reliable and precise data foundation (Melissa P. Johnston 2014). The quantitative data consists of the OCED, European Commission, and renowned company databases, exported as Excel files from the databases. Qualitative data originates from professional reports and literature.

4.2.5 Environmental Factor

Various sources were used to identify which dimensions were relevant to this study by defining the environmental factor and its scope within PESTE analysis. The dimensions used were selected based on qualitative data. In the present study, the environmental factor differs from those commonly used in the PESTE analysis. The chosen approach was needed to understand

better this external factor influencing the DT of Portuguese SMEs. Significant data points were selected and explored after defining the scope of the factor.

This primarily consists of data from Statista, OCED, and European Commission regarding quantitative data collection. The qualitative data was gathered through literature, reports, and articles in the "Google Scholar" and "Nova library search" databases. Yet, given the limited access to consumer-related data within the SME sphere and the digital ecosystem, a study was conducted in the form of a survey, with additional data being gathered via "Google Forms" about the consumer behaviors and readiness towards main DT-related variables. In total, 157 participants answered the survey.

4.3 Data Analysis

The following section describes the process of data analysis in this thesis. The goal is to provide all necessary information about the data analysis in order to ensure the understanding of the content and the structure of the analyzed data for further research. Due to the different characteristics and data basis, various methods were chosen for the individual data analysis of each dimension along with the PESTE analysis.

4.3.1 Political Factor

After gathering all databases, the data was selected and processed. Beyond that, several reliable indices were used to compare the Portuguese case with other EU members and non-EU members.

4.3.2 Economic Factor

As mentioned above, the economic data points originate from different databases, making data preparation necessary before starting with the data analysis. Data preparation is a crucial step within the context of data analysis (S. Zhang, C. Zhang, and Q. Yang 2003) and its most important stage (Brownlee 2020). In order to yield meaningful knowledge and to visualize the

data, the process includes several techniques of transformation after the collection of the data (S. Zhang, C. Zhang, and Q. Yang 2003). The process of data cleaning refers to the identification and correction of mistakes within the respective dataset (Brownlee 2020). The latter did not have to be performed, as the data was available without errors. Appendix 2, Appendix 3, Appendix 4, Appendix 5, and Appendix 6 include code examples for preparing the data originating from the respective databases. The data points were first merged into three individual datasets, as they were assigned to different topics. The first dataset contains twelve economy-related data points for Portugal. Furthermore, the dataset was extended with basic SME-related data. The second data set describes the distribution of SMEs in the individual economic sectors. Latter may seem trivial, but in the context of DT, it takes on greater significance, as the degree of DT is highly dependent on the economic sector. The third set of data describes DT-related data for SMEs in Portugal within sight of the digital economy. The economic datasets were temporarily merged for specific analysis (e.g., correlation matrix). The correlation analysis in section 5.2.4, was conducted for the year 2005-2019, yet the plots of the economic data include the year 2020. As the SME-related data from PORDATA was only available until 2019, the OECD and World Bank data had to be cut to this year.

4.3.3 Social Factor

Gathered data were selected, cleaned, and analyzed. Additionally, datasets from different countries from the EU-27 and the OECD were compared against each other to identify the critical challenges for SMEs in Portugal. The questionnaire data were reviewed, and valuable data were selected and cleaned before contributing to this thesis's content.

4.3.4 Technological Factor

The collected data was analyzed, cleaned, and processed. In addition, numerical indices from different countries from the EU-27 and the OCED and averages were compared to benchmark

Portugal's situation. This was supported by the qualitative data analysis based on the researched content.

4.3.5 Environmental Factor

After the data collection process, it was selected, cleaned, and analyzed. Different data sets from other countries from the OECD were used as guiding principles to compare with the Portuguese situation. A quantitative and descriptive study - the questionnaire - was designed, enabling the collection of primary and mathematical data capable of inducing explanatory results and conclusions for the research problem. The questionnaire data were formulated under six measurement levels (from one to six). The data collected were statistically analyzed using Excel using simple descriptive statistics (mean, average, and standard deviation). The selected data were cleaned before contributing to this thesis's content.

5 PESTE framework applied to Portuguese SMEs

As described in the sections before, the impact of external factors on DT has not yet been examined in current research. Furthermore, recent research often focuses on the difference between large enterprises and SMEs and derives from this knowledge action proposals to adopt digital technologies for SMEs. Due to the different structures of large enterprises and SMEs, recommendations for improving the adoption of digital technologies are then provided based on a comparative analysis of countries that are trailblazers in the DT of SMEs.

5.1 Political Factor

The Portuguese economy relies significantly on SMEs, as was mentioned before. Thus, it is important to understand the Portuguese government's support for SMEs in DT. It is also relevant to know in a quick way how these enterprises survive, namely, what is their funding

structure and an alternative funding source they use. Then, tax benefits conducted by the Portuguese government are presented and, in the end, a comparison between the Italian and Israel government measures and the Portuguese one is made.

5.1.1 Definition

SMEs play an undeniable role in the overall economy in Portugal. Thus, a PESTE analysis regarding the factors that affect them in terms of DT is made. The political factor is the first factor to be analyzed in the PESTE analysis. Given that SMEs constitute a large volume of enterprises in Portugal, an analysis regarding the political factors influencing the survival policy of SMEs is crucial to any government (Zonouzi, Hoseyni, and Khoramshahi 2021). The political factor is significant to be considered since all policies and financial aid issued by the government affect SMEs and their path when it comes to DT (Anas Wajid and Zafar 2021). After an analysis of studies regarding the definition of the Political factor, it can be concluded that it can be described as a factor that includes tax policy, trade restrictions, tariffs, and bureaucracy. Consequently, a deep analysis will be presented in the following section.

5.1.2 Support of the Portuguese government to SMEs

Several plans and programs were and are made through the different years following the need and concern of the Portuguese government relative to SMEs. In this section, it will be presented some programs and plans relevant to SMEs.

One of the biggest concerns of the Portuguese government is SMEs' access to finance. Following this concern, the Portuguese government created in 2008, the year when the global financial crisis started, the "SME Invest/Growth and Capitalizar" program that aims to offer "credit lines[1] with a total stock of bank credit of EUR 20,20 billion, have long-term maturities (up to 7 years) and preferential conditions" (OECD 2020c). PME Investimentos is

[1] "A credit line is a flexible loan option offered by financial institutions to individuals and corporate entities." (Bankrate 2021).

a public financial society under the supervision of Banco de Portugal. Their mission is to support SMEs' capitalization and improve the financial support of the state for them (PME Investimentos 2018). The last credit line was launched by the economy minister on the 11th of July 2018, the Credit Line Capitalizar 2018, having a budget of EUR 3,200,000. The budget is spread through the following lines: SMEs, Industry 4.0, Fundo do Maneio, Planfond de Tesouraria, investments, support to companies exposed to Brexit, and Covid-19 (PME Investimentos 2018). SMEs are enterprises with more difficulty getting access to finance. Their growth perspectives are challenging due to the limited funds. These enterprises became less attractive and can be seen as more problematic by investors for several reasons. First, SMEs are less capitalized and have lower assets than large enterprises, representing a higher risk to the borrowers. Beyond that, there is an asymmetry in information regarding business plans, financial statements, accounting reports, which can be a problem regarding credibility to the borrowers. Lastly, they are exposed to higher variations in terms of survival, growth, and profitability than larger enterprises (Chopra 2021). To facilitate the access of Portuguese SMEs to finance and try to avoid the financial constraints that SMEs face regarding funding and investment, the Portuguese government created a program named “SME Leader” in 2008. This program aims to provide a rigorous evaluation of SMEs in terms of financial and economic matters, providing them a status of excellence if they meet the standards, giving visibility to their merit in the market. It is expected that their access to financial instruments will increase (IAPMEI 2020a). The Portuguese government is also concerned about the capability of SMEs to survive by themselves, the ability to survive with their funding capacity, and because of that, it was created the “Portugal Tech”. Portugal Tech was created in 2018 by the Portuguese government and by the European Investment Fund. This fund is for start-ups, SMEs, and midcaps[2] that are technology-based. It is a venture capital fund of funds (FoF) that focuses on

[2] Mid-caps are companies with a market capitalization between $2 billion and $10 billion (Jackson & Schmidt,2021)

technology transfer, venture capital, and expansion of the capital funds. It also focuses on the failures in the Portuguese market regarding the creation of regulation in terms of venture capital funds (IFD 2018).

Portugal 2020 is a partnership agreement between Portugal and the European Commission. This program brought together the action of five European Structural and Investment Funds. It defines the programming principles related to the economic, social, and territorial development policy implemented in Portugal between 2014 and 2020. Portugal received EUR 25 billion until 2020. One of the priorities of the fund between 2014 and 2020 in terms of competitiveness and internalization was enabling SMEs to operate in global markets (Portugal 2020 2021). In terms of competitiveness and internalization to SMEs, the program Compete 2020 was created, promoting the competitive advantages of SMEs, with a strategic approach focused on initiatives related to Industry 4.0 (Por COMPETE 2020 2021).

It is also worth mention, the industry 4.0 program. The Portuguese government created in 2017 directed to all enterprises (COTEC Portugal 2020). It had a budget of up to EUR 2,26 billion through Portugal 2020 (Interreg Europe 2017) and had two phases. Between 2017 and 2019, the first one was based on HR development, collaborative system, start-up 4.0, financing/investing, internalization, and legal and regulatory adaptation. Between 2020 and 2021, the second phase had several generating, building capacity, and assimilating measures for industry 4.0 (COTEC Portugal 2020). The Covid-19 pandemic brought several challenges to the countries: challenges for the SMEs and their survival. The Portuguese government created several credit lines to support SMEs and entrepreneurs' liquidity. The Portuguese government assigned EUR 1 billion for micro and small enterprises and EUR 1.05 billion for SMEs, small mid-caps, and mid-caps from the industry and tourism sectors with an export share of at least 20.00% in 2019 (OECD 2021e). Beyond this, structural measures for SMEs have been implemented. Portugal Digital is a program that aims to accelerate Portugal "through the digital empowerment of people, the DT of businesses and

the digitalization of the public administration" (Martins 2020). It was created in 2020 as an action plan for DT performed by the Portuguese government. There are three pillars in this action plan. The second one is related to the DT of businesses, focusing on SMEs. In terms of the DT of companies, this is mainly based on measures and investments that aim to encourage the digitalization of enterprises and create awareness and training, especially on SMEs and the development of initiatives that contribute to the scientific and technical business knowledge (Martins 2020). However, the action plan for DT is not the only plan for SMEs in place. For example, it was assigned a EUR 25 million financing package to support the entrepreneurship and start-up ecosystem. The 2030 Economic Internalization Program has been created to integrate SMEs in Global Value Chains (OECD 2021e).

It is also essential to highlight the new European measure, namely, the European Commission funding program, between 2021 and 2027, which focuses on the strength of the competitiveness of European businesses and climate changes. Several programs were created regarding the new funding program. Digital Europe is one of them and focuses on building strategic digital capacities of the EU and facilitating the broad deployment of digital technologies (Morlad n.d.). Lastly, it is vital to refer to AI Portugal 2030. It is a Portuguese national initiative on fostering digital skills that aim to leverage AI. It is an innovative and growth strategy to promote AI in Portugal in the European context. It has several objectives expected to be reached by 2030: added economic growth, scientific excellence, and human development. It is also likely that the use and awareness of AI will be spread through all companies and society, including, SMEsby 2030 (INCoDe.2020).

To sum up, it is crucial to bring to attention the Innovation Index, in the report of the European Innovation Scoreboard from 2016, that considers Portugal as a Moderate Innovator, which means that the performance is below the European average (European Commission 2016a). However, in the report of the European Innovation Scoreboard from 2020, the Innovation Index considers Portugal as a more robust Innovator, which means that

the performance is above or close to the European average (Hugo Hollanders 2020). As shown above, the Portuguese government has invested and supported the innovation and DT to SMEs in the last years through the reinforcement of financial support and the creation of programs that aim to support Portuguese SMEs in the DT process. Therefore, the results and evolution of Portugal through the digital path become visible in European evaluations. Portugal is an innovation-friendly environment and has an attractive research system (Hugo Hollanders 2020).

5.1.3 Funding structure of Portuguese SMEs

The funding structure of SMEs is fundamental to understand, given that several policy measures conducted by the Portuguese government to support the SMEs seek to facilitate their access to financial resources, as mentioned above.

Thereby below, in Figure 3 and Figure 4, it can be found the funding structure of micro SMEs in Portugal between 2015 and 2019 and the financial autonomy of Portugal, Spain, Italy, Germany, and France between 2015 and 2019. As shown in Figure 3, the funding structure (% of total assets) is composed of equity and financial debt. On the one hand, the financial debt decreased 1.00% from 2017 to 2018 and 1.10% from 2018 to 2019. On the other hand, it is also

shown in Figure 3 that equity increases from 2017 to 2018 by 1.70%, and from 2018 to 2019 2.30%. This shows that SMEs have financial autonomy, use less financial debt, and that SMEs look more attractive and riskless to investors. The ideal framework would undoubtedly be where SMEs strengthen their financial health and their capacity to get self-sufficient concerning financial issues.

Nevertheless, an evolution regarding SMEs ' reliance on equity and less on financial debt is in place, contributing to their financial autonomy, as is shown in Figure 4. Portuguese SMEs have good results in terms of financial autonomy, increasing the value year by year. Even though Portuguese SMEs' financial independence is behind between 2015 and 2017

compared to the other countries shown below, in 2018 and 2019, it recovers and presents better values than Italy, Germany, and France.

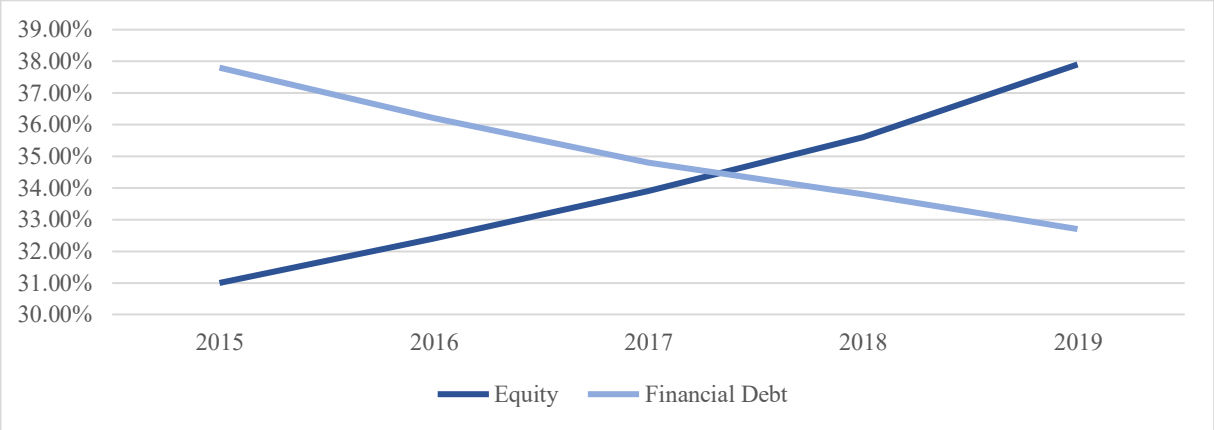


Figure 3: Funding Structure (% of total assets) (Source: Banco Portugal n.d.)

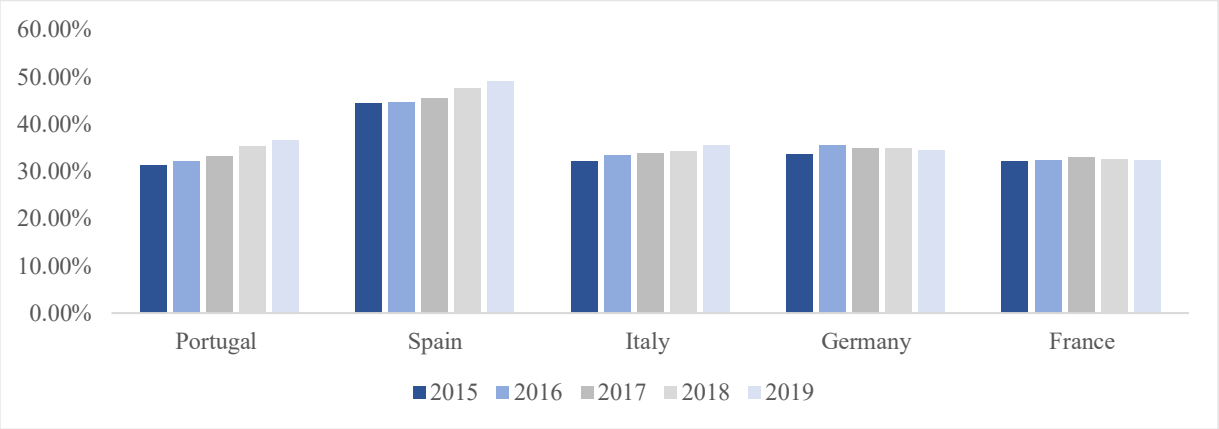


Figure 4: Financial Autonomy (Source: Banco Portugal n.d.)

As shown in Table 8 the availability of bank loans from 2019 to 2020 to SMEs decreases from 8.00% to 5.00%. Beyond that, there is also a substantial decline in the availability of credit lines, from 6.00% to 2.00%. In terms of the difficulty of getting access to finance, it is decreasing, which means that the "rejections of loans applications, loans applications for which only a limited amount was granted and loan applications which resulted in an offer that the SME declined because the borrowing costs were too high. Further, the percentage of SMEs that did not apply for a loan for fear of rejection" (European Commission and European Central Bank 2021) decreased.

Furthermore, Table 8 shows the need for SMEs for bank loans and credit lines, which increases, meaning that SMEs cannot survive only with equity (or equity is not widely available anymore or gets more careful) and with their funds and need to raise financial debt. Suppose the availability of bank loans and credit lines decreases and the need for SMEs to access bank loans and credit lines increases.

In that case, it is possible to associate with a higher need for alternative sources of funding or with the need for financial programs and plans conducted by the Portuguese government, or even by the European Institutions, such as ECB, European Investment Fund, or other international entities such as the International Monetary Fund.

Need				**Availability**				**Financial Obstacles**	
Bank loans		**Credit lines**		**Bank loans**		**Credit lines**			
1	2	1	2	1	2	1	2	1	2
14.00%	26.00%	19.00%	27.00%	8.00%	5.00%	6.00%	2.00%	8.00%	6.00%

Table 8: Need and availability of bank loans, credit lines, financial obstacles (Portugal) (European Commission and European Central Bank 2021)

5.1.4. An alternative source of funding for Portuguese SMEs

Even though bank loans are important to the funding structure of SMEs, SMEs should not rely exclusively on them. As shown in Figure 3, it can be observed an effort from SMEs to use less financial debt, meaning to increase their financial autonomy. Beyond that, it was also represented in Table 8, the decrease of availability of bank loans and credit lines. Therefore, it is important that SMEs find alternative funding sources or even support by the Portuguese government to stay financially stable and avoid high-interest rates.

One of these alternative sources of funding is private equity. There are different types of private equity; nevertheless, venture capital[3] is the type of funding that this thesis will focus on since

[3] "Venture capital mainly comprises equity finance, i.e. taking an ownership interest in a company by buying shares or other forms of participation in the company capital, which is invested at the early stages of innovative start-up companies. Economic studies show that young start-ups that benefit from equity investors fare better than those who have to rely on debt" (European Commission, 2021)

there is room to improve. The investments in venture capital represented 1.00% (% of GDP) in 2017 of the investments in Portuguese companies, while the average EU had a 3.00% investment (European Commission 2019b).

The number of venture capital transactions in Portugal increased. In 2018 the volume was 4.40 times larger than in 2017 (European Commission 2019b). Even though venture capital investments increased, there is still potential for a higher increase (European Commission 2019b). The Covid-19 pandemic had a substantial negative impact on the economy and in the Portuguese enterprises. However, it also brought opportunities, representing an accelerator for venture capital (Pessanha and Silva Gomes 2020). It is shown in Table 9 the distribution of funds to venture capital by private equity firms in some European countries between 2014 and 2018. Portugal has a reasonable value in terms of investments in venture capital, representing 10.30% of total investments between 2014 and 2018. However, Spain, Germany, and Greece have higher values. Nevertheless, there are countries with values below Portugal, for example, Italy or France.

	Portugal	Spain	Italy	Greece	France	Germany
Venture Capital	10.30%	11.20%	2.00%	19.90%	7.70%	12.50%

Table 9: Distribution of venture capital 2014 – 2018 (OECD 2020b)

To conclude, SMEs have capitalization efforts and strengths to rely less on financial debt throughout the past years. The SMEs make these efforts with the support of Portuguese government programs. The programs and support that the Portuguese government gives to SMEs are reflected in SMEs' funding structure and their financial autonomy through the years.

5.1.5.Tax incentives to SMEs

In Portugal, resident entities, and permanent establishment of non-resident entities, certified

as SMEs, pay 17.00% of CIT for the first EUR 15.000 of taxable income and 21.00% for the remaining taxable income (PricewaterhouseCoopers 2017). Thus, this section focuses on the tax benefit of SMEs.

There is a legal regulation, provision 41º - A from the tax breaks law that gives an effective tax break to corporations. It includes all types of corporations, not limited to SMEs. Suppose an enterprise makes a capital increase using a certain tax year (up to EUR 2,000,000). In that case, it can deduct from the taxable profit an amount corresponding to the multiplication by 7.00% of the capital increase amount. This allows the enterprise to pay fewer taxes because it had chosen an option that strength its financial situation (the capital increase will help the company to have more financial capacity to proceed with its activity and to achieve its goals) and move up its financial autonomy, financial power, and financial indexes.

The Tax Regime for investment Support (TRIS) is also worth mentioning. It is a tax benefit approved by Decree-law No. 162/2014 that allows enterprises to deduct a certain amount from the taxable profit and invest in tangible and intangible fixed assets (expenses of technology transfer, such as know-how, acquisition of patents, license, etc.). Since the taxable profit decreases, the amount of taxes will also decrease (Porto City Counsil 2021). Like the TRIS, there is the Deduction for Retained and Reinvested Profits. It is a tax incentive for SMEs, primarily commercial, agricultural, or industrial activity. It allows a deduction of the taxable profit of retained earnings that are reinvested in relevant applications (Porto City Counsil 2021). Beyond that, there are also tax benefits related to the investment in R&D. There is a system that allows the deduction of costs that are eligible, related to R&D of the income subject to the CIT, between the 1st of January 2014 and 31st of December 2025, in a double percentage (Autoridade Tributária e Aduaneira 2020). The basic rate is 32.50% over the amount of the total expenditure of R&D, and the incremental rate is a 50.00% increase in expenditure, compared with the average of the two past years (maximum of one and a half million Euros) (Autoridade Tributária e Aduaneira 2020).

SMEs whose business activities have less than two years and did not benefit from the incremental rate benefit from 47.50% of the basic rate (Autoridade Tributária e Aduaneira 2020).

Several special programs are directed to SMEs regarding exceptional activities and locations, such as tourist companies or corporations located inland to promote the development in locations recently shortage or aging of population or lack of industrial and trade activity. These programs include broad measures given by the government, such as temporary tax exemptions and temporary tax reductions, as well as exemptions and reductions on the payments due to the Welfare Department, and the chance of providing no-reimbursement supports to companies, depending on the applicants' projects and corporations (PwC 2021).

To conclude, SMEs represent a major part of the enterprises in Portugal, and as mentioned before, they struggle every day to survive by themselves. Consequently, the Portuguese government must be aware that SMEs need support in tax benefits. According to the Confederação Portuguesa das Micro, Pequenas e Médias Empresas (CPPME), critical measures as the termination of any advance tax payments by independent workers, Value-Added Tax (VAT) payment only when collected or disclosure of income ratio of every economic area, among others, become essential for achieving fairer and more balanced levels of development in fiscal terms (Correia 2010).

5.1.6. Comparison to Italy and Israel government measures

In Italy, micro and SMEs represent a crucial factor with a major impact on the economy. They account for 99.90% of Italy's total number of active companies. Thus the support of the Italian government is essential (European Investment Bank).

Policy measures conducted by the Italian government directed to SMEs focus on two central pillars, their access to financial resources and the introduction of the industry 4.0 technology (Coacci, D. Lepore, and Shebalina 2021). Concerning the first of those issues, it must be

underlined that the Italian government looks for easing finance or subsided loans to SMEs. Based on these two pillars, the Italian government implemented the National Guaranteed Fund, which aims to turn easier SMEs' access to finance, and the National Plan Industry 4.0, which aims to introduce the industry 4.0 technology. The National Guaranteed Fund was established after the global financial crisis in 2008 and provides SMEs access to financial instruments to facilitate their access to bank loans (Coacci, D. Lepore, and Shebalina 2021). On the other side, the National Plan Industry 4.0 focuses on leveraging the innovation and investments in, for example, R&D, enabling corporations to improve infrastructures, skills, research, etc., as it was carried out between 2017 and 2020 (Coacci, D. Lepore, and Shebalina 2021).

Beyond these two programs, other measures were created and implemented related to incentives to invest in new materials and the integration of digital technology in production processes, subsidies to cover the interest paid for loans granted from banks, expenses related to research and development, tax benefits in terms of expenditures in immaterial goods, know-how, industrial models, patents, etc. (Coacci, D. Lepore, and Shebalina 2021).

In Portugal and Italy, SMEs represent a major part of the total corporations. In fact, through the analysis of these two countries, the conclusion is that the similarities are greater than the differences. Both countries are concerned regarding SMEs' access to finance and leveraging industry 4.0. However, according to the Digital Economy and Society Index (DESI) of 2020, Portugal ranks 19th. Over the last few years, its score has increased in line with the EU average, while Italy ranks 25th compared to the EU-27 member states (European Commission 2020c). Beyond that, Portugal is in 16th place in terms of integration of digital technologies, while Italy is in the 23rd, also in DESI (European Commission 2020c).

It is also important to highlight the example of Israel. Israel defines SMEs in a different way as the European Commission does. To be considered a micro enterprise, it has to have up to four employees. To be considered a small enterprise, it has to have up to 19 employees.

Finally, to be considered a medium enterprise, it has to have 99 employees. In Israel, SMEs also represent the majority of enterprises, accounting for 99.50% of the total number of enterprises (Hugo Hollanders 2020).

Israel is a global leader in climate change mitigation and adjustment technologies since it accommodates highly innovative SMEs (Belman Inbal and Tzachor 2015). It ranks as the 7th most innovative country globally by the Bloomberg Innovation Index of 2021, while Portugal occupies the 37th position (Jamrisko, Lu, and Tanzi 2021). Deloitte considers Israel as "an entrepreneurial powerhouse and a hotbed for pioneering technologies, profitable business opportunities, and high investment return" (Deloitte Israel n.d.). Israel is worldwide known as the startup nation, and this gives the country a vast blast to call for investment and new projects (Deloitte Israel n.d.).

Israel uses a successful national-level policy mechanism to accelerate innovation. The success of Israel is justified by its unique society and culture, government support, strong economy, and "global-first" market approach (Deloitte Israel n.d.). In terms of government support, since 2003, the Israel government has issued loans guarantees in order to support the establishment and development of SMEs. Fundings from the private banks and institutional organs are guaranteed by the governmental Loan Guaranteed Fund (Small and Medium Business Agency, 2018). Also, since the 1990s, the government created the Technology Incubator program[4] , and as of 2021, there are 25 technology incubators all over Israel. These technology incubators provide government fundings of up to 85.00% of early-stage projects costs for two years (Deloitte). Beyond that, the Israel Innovation Authority provides several programs to enterprises, R&D programs, with an annual budget of USD 400 million. Another program that the Israel Innovation Authority put in place is the bi-national

[4] "The incubator's role is to invest in companies in their early-stages and to provide a framework that supports the establishment of the company and the development of the idea into a commercial product." (Israel Innovation Authority)

fund, a joint initiative between the R&D programs and a counterpart from other countries, e.g., China, USA. This program is responsible for financing 50.00% of the R&D expenditures of Israel's enterprises (Deloitte). It is also important to mention that Israel has an investment law, which allows enterprises to benefit from a reduced tax rate and investment grants (Deloitte). In fact, part of the success of SMEs and start-ups in Israel is given by the government's support, in terms, of steady capital flow, which aims to contribute to the progress in technology and science.

Portugal is far behind Israel in terms of innovation and R&D. For example, in terms of expenditures in R&D (% of GDP), Portugal has a national expenditure of 1.35%, while Israel had a national expenditure of 4.94% in 2018 (UNESCO Institute for Statistics 2021). In fact, Israel is considered by UNESCO as one of the global leaders in terms of investment in R&D (Minevich 2020).

To conclude, it is important to bring to attention Table 10, where a comparison between Israel's and Portugal's payment of taxes paid by enterprises is made. The Portuguese total tax and contribution rate (% of the profit) is well above Israel, creating an obstacle for start-ups and SMEs to survive or even to make investments in DT. Israel is not afraid of failure ideas or taking risks towards innovation and DT (Minevich 2020). In fact, the Israel government provides extra monetary help to help entrepreneurs and motivate them to follow their ideas, even if they might fail.

Indicator	Portugal	Israel
Payments (number per year)	8.00	33.00
Time (hours per year)	243.00	235.00
Total tax and contribution rate (% of the profit)	39.80	27.00

Table 10: Tax Payment (World Bank 2018)

5.1.7. Conclusion

SMEs have undeniable importance in the Portuguese economy. A lack in innovation and DT despite the several measures and plans conducted by the Portuguese government is still in place. There is a discrepancy in the field of innovation, science, and technology between Portugal and the EU, considering, for example, the DESI evaluation of 2020, where Portugal ranked in 19th place (European Commission 2020c). There is the need to mitigate the gap that currently exists in terms of DT, especially on SMEs. As it was also shown, the Portuguese government is proactive when addressing SMEs issues. However, several challenges are still in place. On the one hand, the Portuguese performance in terms of access to finance is below the EU average, even though increases are made (European Commission 2019b). On the other hand, the national public policy in the field of DT and R&D still needs improvement, related to strengthening the innovation performance of SMEs by enhancing their technological and management capabilities, the encouragement of the creation of companies related to knowledge-intensive activities, and the encouragement of SMEs to recruit and hire researchers and highly skills employees (Agência Nacional de Inovação 2019). Nevertheless, it is also expected that the Portuguese government's future measures will continue to focus on reinforcing open innovation to SMEs, such as industry 4.0 and the integration of IT systems.

6. Recommendations

This section represents recommendations for private and public institutions that were developed based on the results of the previous data analysis. Best-practice solutions have been considered and adapted to the situation in Portugal. Furthermore, the researchers suggest implementing the recommendations in consecutive order, as displayed in Figure 23They build on each other and thus represent an optimal road map towards the digital economy for SMEs.

Figure 23: Recommendations Roadmap (Source: own illustration)

It has to be stated that there might already be initiatives Portugal drives that have a similar intention and are built on similar pillars to the following recommendation. Nevertheless, the recommendations proposed in this chapter are delineated to those existing or planned. Lastly, the recommendations are based on best practices from other EU-27 countries. When the thesis was conducted, these recommendations had not been implemented nor planned for Portugal.

6.1. It’s all about data

Collected data is mainly unstructured or semi-structured, complicating its analysis to extract meaningful information. Especially when statistical methods such as machine learning are applied, data must be clean since the algorithms require structured data to interpret it correctly. These statistical methods have already been applied in many medical or engineering fields, but their application to socio-economic data is still in the early stages – despite the vast potential (Blazquez and Domenech 2018). However, interdisciplinary data collection methods have to be applied to realize the full potential of the data collected and the data already available (OECD 2019a). Otherwise, be economic costs arise, which implies a high loss in prospective chances. For this reason, the entire data lifecycle must be taken into account, which is already being demanded by many researchers, economists, and various institutions (Blazquez and Domenech

2018). Given the pace of technological change, these new interdisciplinary data collection approaches are essential. The latter shows that current frameworks are not yet capable of revealing the full magnitude of DT (OECD 2019a). For example, creating the economic dataset within the scope of this work was very challenging, as data is stored in different formats on different databases. No database has a complete set of data that allows a full socio-economic analysis using statistical methods. The OECD emphasizes the importance of national data collection standards, which should be compiled into statistical indicators (OECD 2019a).

It became apparent that the DT of SMEs in Portugal differs within the economic sectors. In connection with interdisciplinary methods for collecting data, van Iseghem et al. (2011) conducted an interesting study. A French research institute implemented a data collection framework called DCF "collect, manage, and share data within the fisheries sector" (European Commission) of the EU within the French fishing sector to gather economic data. The result was that they could make precise statements about the individual ship types, the yield, the waste, etc. – thus, they had a basis for strategic decisions. Furthermore, the gathered data from several fishing boats could be generalized and representative for the entire French fishing fleet. Digital footprints are left everywhere these days, leading to an exponential increase in the total amount of data available for economic analysis. As can be seen, the potential also exists for sectors that are traditionally difficult to digitize. Again, the example of the French fishing fleet has also shown that how the data is generated has important implications for the statistical quality (Blazquez and Domenech 2018).

From a macroeconomic perspective, today's measurement methods do not show the SMEs' DT's impact on the economy (Boissière 2014). Here, the French example shows that the most robust evidence of the economic impact will first appear on a micro level before surfacing in macro-data (OECD 2019a). However, the compilation of our macro dataset showed that only a few DT-related data points are available in the context of SMEs in Portugal. The wide variety

of heterogeneous data cannot be tackled with current methods, only with considerable time investment. As for the French fishing sector, an entire end-to-end process could be implemented, reaching from the data extraction to the final analysis. Such an approach would allow the generalization of the gathered information (Blazquez and Domenech 2018).

Furthermore, in their DT of SMEs report, the OECD (2021d) promotes a whole government approach. To understand the Portuguese government data tracks, analysis regarding Portugal government data accessibility, data availability, and government support for data reuse will be made. Portugal is in 23rd place compared to the OECD countries in 2019 regarding data availability, data accessibility, and government support for data reuse. It is important to understand that in terms of data availability, the Portuguese government improved between 2017 and 2019, from 0.11 to 0.16 (the indicator varies from 0.00 to 0.33). However, it is still below the OECD average (0.20 in 2019). In terms of data accessibility, the Portuguese government improved between 2017 and 2019, from 0.20 to 0.27 (the indicator varies from 0.00 to 0.33), being above the OECD average (0.23 in 2019). Lastly, the government support for data reuse is the same between 2017 and 2019, and 0.08 is below the OECD average (0.17 in 2019) (the indicator varies from 0.00 to 0.33) (OECD 2019b).

Several measures were conducted through the years to open Portuguese government data. The Administrative Modernization Agency (AMA) within the Ministry of State and Public Administration Modernization coordinates and promotes open government data initiatives in Portugal. The Portuguese open data policy is embedded in the digital government strategy ICT Strategy 2020 to enable innovation and competitiveness. The Law of Access to Public Documents requires public institutions to release information in re-usable and open formats whenever possible. The National Regulation for Digital Interoperability sets public sector data interoperability standards to facilitate public sector data sharing and re-use (OECD 2019b).

6.2. Tech Hubs

The second recommendation represents Tech Hubs for rural areas with programs for the different regions to push digital education for all age groups and social backgrounds.

The previous analysis (chapter five) indicates the possibility of a gap in (primary) digital skills between rural and urban areas (5.3.1). Another possible education gap was found comparing the different age groups. Older people in Portugal seem to be less educated, especially in digital areas, than the younger generations. The gap becomes even more apparent comparing the Portuguese data to Finland, the number one country regarding DT in 2020 (European Commission 2020). Lastly, the conclusion that there is a gap in basic digital skills might be drawn based on the findings from chapter 5.4.

Additionally, most SMEs are family-owned, suggesting that they are not start-ups. Hence their business model is not necessarily technology-based. Family-owned businesses tend to be characterized by solid hierarchies, cultural values, and business owners with no or primary digital education. Hence, they might be more digital adverse, and including new ways of working, technologies, and mindsets in the organization culture could be a challenge. The knowledge transfer through public schemes or DIHs mainly focuses on entrepreneurship, innovation, and start-ups, primarily located in urban areas. Initiatives supported by the Portuguese government seem to be more focused on funding rather than education. Moreover, digital innovation hubs in Portugal focusing on DT are mainly based in urban areas. The research revealed that the long distance to the next possible digital education service in rural areas is one of the reasons SMEs and their employees/owners do not participate in training. Lastly, the European Commission fosters EDIHs, which mainly focus on emerging technologies and are not adapted to the state of SMEs in Portugal, as they are still falling behind in normal digitalization. This manifests that approximately 40.00% of SMEs are not even equipped with a computer.

Based on the analyzed challenges, examples from frontier countries were researched to recommend how digital hubs can promote digital literacy among Portugal's rural and adult population. Portugal introduced new measurements each year to further enhance their digital education and digital literacy (e.g., Digital Academy) (Pedro Andrade et al. 2021). However, as analyzed in this thesis, there is still much room to improve. Therefore, the research group identified practice DIHs for older adults.

The first example, which could be used in Portugal, was successfully introduced in Finland. The project was introduced in 2014, and it started in 2017 and lasted for one year. In total, EUR 27,100 was spent on this project. With 1,300 people, Suodenniemi, Finland, is a small village with limited digital education possibilities. Digitalization and online services are crucial skills and techniques for people, especially the elderly in rural areas. The Suodenniemi community launched a DIH for older people to tackle this problem. The idea was to establish a digital hub and advisory point in the village library. The project aimed at the following targets:

1. Improve the digital device literacy of Suodenniemi residents, especially the elderly;
2. Develop and adopt new digital skills in a village that suffered from people moving away and many public and private services being closed down;
3. Improve the library and its services

The new service was announced through the villages Association channels, including social media, pensioners' associations, and newspaper articles. An IT professional was hired to work in the library, and he assisted with everyday IT problems for two days a week – Tuesdays and Thursdays. Additionally, the library organized mobile payments, E-security, E-health systems, etc.

The project's main results were that the IT specialist could assist three customers per day. After one year, most older people living in the village started to use online services and showed

willingness and motivation to learn new things. The project created a positive attitude towards digitalization (Johanna K Seppa 2020).

The second example would be the Adult Liberal Education program from Finland. The model displays possibilities for governments to promote digital literacy among the labor in the country. Finland launched a unique program at the end of 2018 to strengthen the basic skills, multiliteracy skills, and digital skills of adult citizens with inadequate skills. The training was more accessible to people of all ages. Adults can participate in Adult Liberal Education – participation is voluntary, and no pre-education is required. The offers increasingly include basic digital skills for the elderly. The training can be attained so far at many different places – folk high schools, adult education centers maintained by local authorities, learning centers maintained by private civic organizations, summer universities, and sports training centers (Susanne Anthony et al. 2019; Annika Bussman, Petra Heikkinen, and Samuli Rasila). This training could be combined with the Icelandic 'Lifelong Learning Strategy'. Around the whole country, centers for lifelong learning and centers for continuing education have been established. They vary in organizational structure. However, all receive support from the local government in question, employees' associations, colleges of further education, and companies (EURYDICE 2019). With help from the government and other sources, it is possible to maintain a state-of-the-art digital education and provide it all across the country.

Building a DIH comparable to this in Portuguese villages could lead to the same results. Introducing technological possibilities to older people may be crucial to promote digital literacy and teach basic digital skills. Good explanations and best practices might take their fear of new ways of working and change the view on digital products. Hence, SME owners and employers could be more willing to include digital tools in their companies (Johanna K Seppa 2020).

The research group proposes that the initiators for the implementation of the DIH apply for funding through the Digital Europe Program. The budget granted is foreseen for three years,

whereby there is a possibility to reapply after the duration ends. The suggested hub would fulfill the requirements stated by the European Commission. Namely, it must be local to support DT and focus on expertise (key enabling technologies and basic digital skills). In line with the recommendation of the European Commission, next to the fund to the Digital Europe Program, private external investors were encouraged to be co-invest in the DIH. This might also favor larger private companies, similar to the privately financed program mentioned in section 5.4.3.3, to support the DT of their suppliers and immediately connected value chain.

6.3. Tailored Training

This recommendation suggests introducing specific training based on the different sectors in Portugal and more targeted to the needs of SMEs. The previous analysis shows that the programs for SMEs are very general or tackle startups. DIHs that target specific sectors tend to focus on R&D mainly and do not provide any initiatives to transfer knowledge with the context of DT. A study concludes that SMEs demand customized solutions geared towards integration due to their specific characteristics (Crupi et al. 2020). Moreover, findings revealed that SMEs seem to profit more from a tailored program according to their region and sector. The analysis has also shown that SMEs do not see the cost-benefit of current programs. Lastly, existing programs and training that are more targeted are mostly privately financed by large companies to support their supply chain. They are therefore only accessible to a tiny target of SMEs.

Tailored training would be linked to the two previous recommendations. With more data (it's all about data), a more specific activity could be developed for different sectors in Portugal. These may be executed and provided by the DIHs mentioned in recommendation two. It would benefit and contribute to the “it’s all about data” recommendation, with interdisciplinary data collection standards to ensure knowledge transfer. These programs could provide precise data for rural areas and specific sectors, enhancing the programs further.

The group has identified the CORA program as a possible best practice. CORA represents a model that provides a comprehensive set of guiding measures towards digitalization in rural areas, based on three pillars identified as necessary: Digital Infrastructure, Digital Skills, and Digital services. The concept comprises three main steps: identifying the common local challenges, testing solutions to overcome the obstacles, and streamlining and knowledge transfer (Peyman Khodabakhsh et al. 2021).

Another example of successfully introducing a program is Finland's 'Digital Visiting' Program. The project ran from 2019 until 2021 and used a budget of EUR 300.000 in total. It demonstrated a need in remote rural areas for local digital support to develop residents' digital skills. The aim was to improve the participating village residents' digital skills and pro-digitalization attitude. In turn, this will improve their access to different types of electronic services. The activities and workshops were individually planned with each village that participated. Chosen topics varied between villages. The group sizes were at a maximum of 15 people to ensure enough individual help if needed. Additionally, digital tutor activities have been started, where digital competent village residents helped other residents.

After the project, the main effects were measurable. During the two-year framework, around 100 digital skills training, digital service days, or digital tutor days were organized. Over 2.700 rural residents were reached throughout the whole project. But most importantly, the feedback from participants showed that the project "helped to improve digital skills, enable pro-digitalization attitude among the rural village residents and fostered a willingness to try to adopt new electronic services" (Susanna Nurmeksela 2021).

The research team would propose using the DIH across Portugal described in recommendation 6.2 and implementing the stated tailored training. Portugal has different regions with different focus areas regarding the job and sector-specific skill requirements. While the northern regions are well-known for wine, the south has a vast cork industry. Furthermore, the coastline focuses

on fishing, requiring different digital skills than the other industries. Hence, data collection and analysis are necessary to identify the practical digital skills, which then can be implemented through the training in the hubs.

6.4 Rebuilding Trust on Online Platforms

The final recommendation strengthens consumer reliance on tools enabled by digital technologies such as online platforms. As a final stage of this recommendations' roadmap for the DT of SMEs in Portugal, and after establishing new approaches to data collection, implementing successful training and higher basic digital skills, it is vital that once the foundations of DT are fortified, consumers are inhibited from constraints and therefore prepared to embrace the full benefits of DT.

The previous analysis in Section 5.5 found a significant feeling of unsafety by consumers when online shopping. However, according to the global cyber security index and the previous analysis in chapter 5.4.2, cybersecurity is a vital feature of the Portuguese market through data showing that Portugal has high cybersecurity(International Telecommunication Union 2021). Moreover, section 5.4. revealed that the Portuguese population demands fewer E-commerce transactions than the EU-27 average and the frontier country Denmark.

The government can play a significant role by boosting SMEs' DT by helping to scale up SME internal capacity. This can be achieved by raising SMEs' digital security profile through awareness campaigns or giving them information and tools on practical digital security measures such as toolkits, auditing, assurance seals, protocols, and certification schemes, and training possibilities (OECD 2021d).

The perceived risk connected with online selling is a block to E-expansion. Buyers value the trustworthiness of internet shops, especially when dealing with unknown suppliers. To manage situations where buyers feel uncertain or unsafe, assurance seals (issued by a trustworthy third party such as the Government) have been created for use on websites.

According to Balboni and Dragan, privacy and security seals serve two crucial functions: they provide assurance that the seller's practices comply with acceptable privacy standards or norms, and they influence users' perceptions of risk associated with a website, encouraging them to disclose information (Balboni and Dragan 2018). Moreover, an assurance seal establishes corporate social responsibility by exhibiting a company's commitment to a specific code of conduct.

According to a study, around 70.00% of online shoppers abandon their orders because they do not trust the company (john Rampton 2014). Previous research has found that shoppers are more likely to trust a website if they feel comfortable (McKnight et al. 2017; Hong and Cha 2013). A seal shows a retailer's trustworthiness and security in facilitating safe and successful Internet transactions. The purpose of using a voluntary seal like this is to boost potential purchasers' trust and make the transaction process more pleasant for them (Kim, Ferrin, and Rao 2008; Yianna Danidou and Burkhard Schafer 2012). As a result, internet businesses that use assurance seals reduce their perceived risk. Overall, this could lead to higher demand in E-commerce transactions by increasing the perceived safety in combination with higher digital skills.

In conclusion, Portugal's digital infrastructure provides a solid basis for driving forward the digital transformation. This also manifests in heavy investment in data centers and ICT infrastructure by the Portuguese Government and private communication providers. Portugal is developing as an essential connection between Europe and South America. Further, indices and the preceding analysis have shown that Portugal has great potential for a digital economy exceeding frontier countries. The developed recommendations build on these findings and form a proposal to close the previously identified gaps and accelerate Portugal’s strategic position.

6.5 Limitations

The topic ‘Factors influencing the DT of SMEs in Portugal’ has many sub-areas that need to be covered. Due to time, resources, and space limitations, the analyzed areas only cover individual data points selected by each research group member based on the methods described in section 4. Hence, not all areas are covered and investigated in this thesis. One of the main obstacles regarding the economic data points was the scattered nature of the source of the datasets, which made intensive processing of the data sets unavoidable. In section 5.2.5, the so-called digital economy has been addressed. It is essential to mention that it is challenging to quantify the digital economy in SMEs in Portugal (Boissière 2014). Research has consistently shown an absence of ICT-specific data, especially related to SMEs in Portugal. Latter presented one of the biggest challenges for the analysis. Indeed, the lack of these DT-related data points significantly impacts the statistical power and complicates the study's analysis.

Another limitation is the lack of a database for privately financed programs in section 5.4.3.3.

Further limitations are concerning the questionnaire. Even though 157 people participated, it is only a small amount and does not represent all SMEs. Therefore, the here defined recommendations and findings are limited to the information gathered by the participants. Hence, all information, recommendations, and conclusions expressed and stated are limited to the used and described sources and individual interpretation of those. Further limitations are described in the respective chapters.

When writing the thesis, the current Digital Economy and Society Index (DESI) from the European Commission was from 2020. On the 12th of November 2021, the new Index for 2021 was published (Shaping Europe’s digital future 2021). As many sources, analyses, and findings rely on the DESI, the thesis and its outcomes are limited to the 2020 version.

6.6 Future Research

With this thesis, the authors have achieved the first objective by providing a systematic and holistic method for analyzing external factors related to DT on SMEs by applying the PESTE method; and the second objective elaborates the recommendations to accelerate the proposed process using Portugal as an example. The research presented in this paper encourages further research on external factors and their effects. Improvements in identifying external factors can be made to increase the credibility of the results through a consensus of experts, researchers, private and public institutions, using methods such as the Delphi method. The results obtained in this thesis are applied explicitly to Portugal. Yet, the research process can be replicated to analyze similar or specific challenges in any other country and further develop the concept. The authors relied on data collection techniques and research representation to achieve the best possible reliability and validity, intending to obtain accurate and reliable data. Nevertheless, further research using qualitative and quantitative approaches could be helpful to complement and validate the findings. One possible method could be collecting more primary data in a nationwide study.

7. Conclusion

"There is no alternative to digital transformation. Visionary companies will carve out new strategic options for themselves — those that do not adapt will fail." – Jeff Bezos

One thing is abundantly clear. There is no way around DT; digitalization is all around, whether a large global company or a small micro-business. This is amplified by emerging technologies, Covid-19, and changing customer expectations at the core. External factors impact the DT and lay the foundation for SMEs. Portugal offers a solid foundation, although there is still room for improvement, especially in other EU countries.

Considering the political factor, it is evident that the Portuguese government provided several programs and plans, including tax benefits, to support SMEs. The program's main focuses are

reinforcing SMEs' access to finance and helping them become more digitalized, creating programs related to DT, R&D, and Industry 4.0. Even though the Portuguese government makes evident efforts, improvements are still needed. When comparing Portugal with other countries, it can be understood that a lack of SMEs access to finance or its position in terms of innovation, science, and technology is still in place. Furthermore, it is expected that DT and innovation will become the main focuses of the Portuguese government in future policies.

From a socio-economic perspective, the analysis clarified that Portugal has a great opportunity and the potential to drive the country's DT towards the digital economy. In the form of basic digital technologies for SMEs, the basis of such a digital economy has developed in Portugal in recent years. It also became evident that SMEs can be a decisive factor for Portugal in such transformations. However, socio-economic data points and data collection are still scattered, which heavily complicates its analysis, and potential opportunities can be missed. SMEs would highly profit from a uniform cross-sector data collection process, as they would have a solid basis for strategic decisions regarding their DT based on economic data. The mentioned examples and the conducted analyses in this thesis have shown a potential link between economic development and the level of DT of SMEs in Portugal, underlining the importance of a uniform data acquisition.

Social factors from different angles influence the Portuguese SMEs. It was possible to identify two core problems in Portugal that might concern the Portuguese society's digital skills: A gap between the different age groups and rural and urban areas. Comparing Portugal with the OECD or the EU, one can see that the education system is lagging. Despite significant improvements in recent years, there is still a lot to be done. Especially for SMEs, this development is of crucial importance. Better education in the country means more skills and a better-trained workforce. With the main two identified pain points in mind, it should be considered to implement further adult education with a highlight on digital skills. Furthermore, it could be beneficial to involve

the rural areas more in digital education to promote DT.

Portugal has a solid foundation in terms of digital infrastructure. It is well above the EU average, yet it does not touch frontier countries, especially from the Scandinavian area. Portugal's government is investing heavily in digital infrastructure, making Portugal a strategic location for data centers and a bridge between Europe and South America. 5G is one of the most critical technologies and enablers and represents an excellent potential for SMEs. Portugal was very late in completing the auction of 5G lots and is second to last in the EU-27 in 5G readiness, so it is essential to close the gap quickly. Further, the Portuguese government already offers an above-average eGovernment service, thus supporting a digital infrastructure to support SMEs to reduce administrative burden. Knowledge transfer in the technological field has more significant gaps than in Scandinavian countries. Comparatively, there are fewer digital innovation hubs per SME than in the lead countries, and these often focus on R&D or entrepreneurship. Moreover, they are usually located in urban areas and thus difficult to access for many SMEs. In addition, the Portuguese government and its programs are more focused on financial funding and R&D to drive innovations rather than addressing the lack of basic digital skills.

From the Environmental side, Portuguese consumers display an emergent trend in the use and integration of digital technologies provided by DT in their daily lives. The consumer's readiness and behaviors towards DT are remarkable, and their demands and improvement points for unrestricted use and experience. Compared with other OECD countries, Portuguese SMEs lack ICT exploitation for their benefit, technologies that provide a closer understanding and connection with consumers. The non-uniformity of structural characteristics offered by ICT, such as comprehensive platforms and standardized and easily accessible payment methods, is needed to accompany the European digital leaders. A comprehensive approach for the DT process to succeed in the Portuguese context is lacking. So, an incremental effort is desirable

to offer the necessary tools and platforms that stay beside consumer trends. The Government has an essential role in driving the foundations needed to reduce the gaps between SMEs and large companies.

However, based on the findings in this thesis, there might be the possibility to close the identified gaps by following the roadmap towards a digital economy proposed. This would necessitate close cooperation between different actors from private investors, the public sector, and SMEs. A stable external environment as a foundation of external factors in collaboration with frameworks, guidelines, and tools that focus on the right strategy, mindset, and other internal factors could help SMEs complete the DT faster. Furthermore, those could help reap the benefits that come with it and continue to be a significant pillar of society and the economy. Lastly, Portugal has a high potential towards a digital economy upon all stakeholders should develop on.

8. Appendix

Appendix 1: Data points dictionary

Dataset	Data points	Definition
Portugal economic data	Internet access (Households) (%)	"Internet access is defined as the percentage of households who reported that they had access to the Internet. In almost all cases, this access is via a personal computer, either using a dial-up, ADSL, or cable broadband access. This indicator is measured in percentage of all households." (OECD Data n.d.d)
	Inflation (%)	"Inflation measured by consumer price index (CPI) is defined as the change in the prices of a basket of goods and services that are typically purchased by specific groups of households. Inflation is measured in terms of the annual growth rate and index, 2015 base year with a breakdown for food, energy and total excluding food and energy." (OECD Data n.d.c)
	Unemployment Rate (%)	"The unemployed are people of working age who are without work, are available for work, and have taken specific steps to find work. The uniform application of this definition results in estimates of unemployment rates that are more internationally comparable than estimates based on national definitions of unemployment." (OECD Data n.d.g)
	Nominal GDP Growth Rate (%)	"Nominal gross domestic product (GDP) is GDP given in current prices, without adjustment for inflation. Current price estimates of GDP are obtained by expressing values of all goods and services produced in the current reporting period." (OECD Data n.d.f)
	Corporate Net Lending (% of GDP)	"Net lending is the net amount a unit or a sector has available to finance, directly or indirectly, other units or other sectors. Net lending can be derived as saving plus net receipts of capital transfers minus net purchases of non-financial assets (i.e. the balance of the capital account), or it can be measured as the difference between net acquisition of financial assets and net incurrence of liabilities (i.e. the balance of the financial account)." (OECD Data n.d.e)
	GDP per Capita (US-Dollar)	"Gross domestic product (GDP) is the standard measure of the value-added created through the production of goods and services in a country during a certain period. As such, it also measures the income earned from that production or the total amount spent on final goods and services (less imports). While GDP is the single most important indicator to capture economic activity, it falls short of providing a suitable measure of people's material well-being for which

		alternative indicators may be more appropriate. This indicator is based on nominal GDP (also called GDP at current prices or GDP in value) and is available in different measures: US dollars and US dollars per capita (current PPPs).” (OECD Data n.d.b)
	Average Wages (US-Dollar)	“Average wages are obtained by dividing the national-accounts-based total wage bill by the average number of employees in the total economy, which is then multiplied by the ratio of the average usual weekly hours per full-time employee to the average usually weekly hours for all employees. This indicator is measured in USD constant prices using 2016 base year and Purchasing Power Parities (PPPs) for private consumption of the same year.” (OECD Data n.d.a)
	FDI Portugal (US-Dollar)	“Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor.” (World Bank)
	Number of SMEs by size	Micro, small and medium are defined in Section 3.2.1 (Definition).
	SME Investment Rate (%)	“Measures the relationship between gross fixed capital formation and gross value added.” (PORDATA 2021e)
	SME GVA (€)	“Gross production value less the cost of raw materials and other consumption in the production process. Values are gross when not deducting the consumption of fixed capital.” (PORDATA 2021c)
	SME Turnover (€)	“The net amount of sales and services rendered (covering compensatory allowances) relating to entities' normal business after reductions in sales and not including the value-added tax nor other taxes directly related to sales and services rendered.” (PORDATA 2021d)
SMEs per sector	-	“An activity can be said to take place when resources such as equipment, labor, manufacturing techniques, information networks, or products are combined, leading to the creation of specific goods or services. An activity is characterized by the input of products (goods and services), a production process, and an output of products. An industry consists of a group of local kind-of-activity units engaged in the same, or similar, kind-of-activity.” (PORDATA 2021f)
SMEs and ICT	SME Computer Usage (%)	“Enterprises that use computers as a % of the total of enterprises.” (PORDATA)
	SME Computer Usage (%-change)	
	SME Internet Connection (%)	“Enterprises with an Internet connection as a % of the total of enterprises.” (PORDATA)

	SME Internet Connection (%-change)	

Appendix 2: PORDATA – Code example for data preparation (Python)

```
# Reading the CSV file
    prt_SMEIR= pd.read_excel("PORDATA_SME_Investment_Rate.xlsx", header=None)
# Drop rows
    prt_SMEIR = prt_SMEIR.drop([0,1,2,3,4,5,6,7,8], axis=0)
# Number of rows to drop
    n = 22
# Dropping last n rows
    prt_SMEIR.drop(prt_SMEIR.tail(n).index, inplace = True)
# Number of columns to drop
    n = 251
# Drop last N columns of dataframe
    prt_SMEIR = prt_SMEIR.iloc[: , :-n]
# Adding Column and defining index where the column should be added
    idx = 0
# Content of new column
    new_col = ["PRT", "PRT", "PRT", "PRT", "PRT", "PRT", "PRT", "PRT", "PRT",
    "PRT", "PRT", "PRT", "PRT", "PRT", "PRT"]
    prt_SMEIR.insert(loc=idx, column="Country", value=new_col)
# Adding column name to the respective columns
    prt_SMEIR.columns = ["Country", "Year", "IR-Total (%)", "IR-Micro (%)", "IR-Small
    (%)", IR-Medium (%)"]
    prt_SMEIR
```

Appendix 3: OECD – Code example for data preparation (Python)

```
# Reading CSV
    prt_IF = pd.read_csv("OECD_Inflation.csv")
    prt_IF = prt_IF.loc[prt_IF["LOCATION"] == "PRT"]
# Removing Columns
    prt_IF = prt_IF.drop("Flag Codes", 1)
    prt_IF = prt_IF.drop("FREQUENCY", 1)
    prt_IF = prt_IF.drop("MEASURE", 1)
    prt_IF = prt_IF.drop("SUBJECT", 1)
    prt_IF = prt_IF.drop("INDICATOR", 1)
# Renaming Columns
    prt_IF = prt_IF.rename(columns={"LOCATION": "Country", "TIME": "Year",
    "Value": "Inflation (%)"})
    prt_IF
```

Appendix 4: World Bank – Code example for data preparation (Python)

```
# Reading CSV
        prt_FDI = pd.read_excel("World_Bank_FDI.xls", header=None)
        prt_FDI = prt_FDI.loc[prt_FDI[0] == "Portugal"]
# Defining columns to drop
        n = 1
# Drop last N columns of dataframe
        prt_FDI = prt_FDI.iloc[: , :-n]
# Dropping columns in the beginning
        prt_FDI.drop(prt_FDI.iloc[:, 3:20], inplace = True, axis = 1)
# Transformung columns into rows (due to the format of the dataset)
        prt_FDI = prt_FDI.T
# Drop first rows of dataframe
N = 32
        prt_FDI.drop(index=prt_FDI.index[:N], axis=0, inplace=True)
# Inserting Country code
        prt_FDI.insert(0,"Country","PRT")
# Inserting the Year range
        prt_FDI.insert(1, "Year", range(2005, 2005 + len(prt_FDI)))
# Renaming FDI column
        prt_FDI.rename(columns={ prt_FDI.columns[2]: "FDI Portugal (US-Dollar)" },
        inplace = True)
        prt_FDI
```

Appendix 5: Merging the datasets – Code example for merging the datasets (Python)

```
# Initial Dataset merging
        left_merged = pd.merge(prt_IA, prt_IF, how="left", on=["Year", "Country"])
# Adding all other datasets to create a final dataset df
# Adding Unemployment Rate to the dataset
        IA_IF_UER = pd.merge(left_merged, prt_UER, how="left", on=["Year", "Country"])
```

Appendix 6: Visualizing the data – Code example for plotting the data (Python)

```
# Defining the style of the plot
        sn.set_style("whitegrid")
        sn.set_context("paper", font_scale=1.5, rc={"lines.linewiDT h": 1.5})
# Defining x-Axis
        x = prt_IA[["Year"]]
        plt.rcParams.update({"font.family":"Times New Roman"})
# Plotting the data
        plt.Figure(figsize = (15, 5))
        plt.xlabel("Years", fontsize=20)
        plt.xticks(fontsize=14)
        plt.ylabel("Internet Access Households (%)", fontsize=20)
        plt.yticks(fontsize=14)
        plt.plot(x, prt_IA[["Internet Access (Households) (%)"]], "bo-", color="r")
        plt.savefig("Internet_Access_Households.png")
        plt.show()
```

Appendix 7: Dataset – Portugal Economic Data

Source: Appendix 1

Country	Year	Internet Access (Households) (%)	Inflation (%)	Unemployment Rate (%)	Nominal GDP Growth Rate (%)	Corporate Net Lending (% of GDP)	GDP per Capita (US-Dollar)	Average Wages (US-Dollar)	FDI Portugal (US-Dollar)	#-Total	#-Micro	#-Small	#-Medium	IR-Total (%)	IR-Micro (%)	IR-Small (%)	IR-Medium (%)	GVA-Total (€)	GVA-Micro (€)	GVA-Small (€)	GVA-Medium (€)	Turnover-Total (€)	Turnover-Micro (€)	Turnover-Small (€)	Turnover-Medium (€)
PRT	2005	31,46	2,13	9,23	4,14	-3,36	$ 22.725	$ 28.148	$ 3.367.937.007	1.150.515	1.099.975	44.149	6.391	25,00	22,40	22,30	31,00	52.401 €	19.775 €	16.539 €	16.088 €	208.336 €	73.594 €	69.317 €	65.424 €
PRT	2006	35,15	3,05	9,30	4,86	-5,76	$ 24.650	$ 27.536	$13.394.502.768	1.171.093	1.119.032	45.513	6.548	26,60	26,80	25,50	27,50	54.709 €	20.093 €	17.457 €	17.160 €	216.428 €	74.133 €	72.285 €	70.011 €
PRT	2007	39,61	2,42	9,58	5,55	-5,91	$ 25.702	$ 27.720	$ 6.014.642.427	1.233.432	1.180.255	46.398	6.779	27,60	28,40	24,20	30,00	58.631 €	21.228 €	18.879 €	18.523 €	228.368 €	77.007 €	76.264 €	75.097 €
PRT	2008	46,04	2,65	9,24	2,06	-7,51	$ 26.666	$ 27.631	$ 7.819.075.463	1.260.302	1.207.098	46.383	6.821	26,60	29,10	23,60	26,80	60.471 €	21.798 €	19.613 €	19.061 €	232.696 €	77.048 €	77.145 €	78.503 €
PRT	2009	47,89	-0,90	11,23	-2,06	-3,55	$ 26.478	$ 28.913	$ 5.585.829.214	1.222.488	1.171.689	44.253	6.546	25,00	26,50	20,60	27,60	57.957 €	21.411 €	18.319 €	18.227 €	216.220 €	72.253 €	70.858 €	73.109 €
PRT	2010	53,73	1,39	12,58	2,39	-0,64	$ 27.283	$ 28.792	$ 8.966.915.539	1.167.168	1.117.787	42.968	6.413	21,50	28,00	17,50	18,40	56.854 €	20.311 €	17.959 €	18.584 €	219.744 €	71.940 €	72.364 €	75.440 €
PRT	2011	57,97	3,55	13,52	-1,96	1,16	$ 26.769	$ 28.096	$ 9.821.076.890	1.135.153	1.088.145	40.815	6.193	18,80	20,70	17,20	18,40	52.814 €	18.138 €	17.260 €	17.416 €	208.317 €	66.917 €	68.819 €	72.581 €
PRT	2012	61,02	2,78	16,58	-4,43	2,25	$ 26.438	$ 26.890	$21.396.375.527	1.085.894	1.043.003	37.118	5.773	13,70	17,50	11,80	11,70	47.346 €	16.038 €	14.920 €	16.388 €	191.973 €	61.385 €	63.057 €	67.531 €
PRT	2013	62,34	0,44	17,18	1,31	3,32	$ 27.936	$ 27.406	$15.745.220.666	1.118.427	1.077.294	35.446	5.687	15,00	19,70	11,30	13,70	48.183 €	15.869 €	15.767 €	16.547 €	190.187 €	60.738 €	62.221 €	67.228 €
PRT	2014	64,87	-0,16	14,65	1,50	6,24	$ 28.742	$ 26.935	$12.045.808.665	1.146.119	1.104.490	35.870	5.759	16,60	23,00	13,90	12,80	49.451 €	16.715 €	15.694 €	17.042 €	194.812 €	62.461 €	63.895 €	68.456 €
PRT	2015	70,23	0,51	13,03	3,85	3,32	$ 29.661	$ 26.855	$ 1.270.014.233	1.180.331	1.136.865	37.515	5.951	18,10	24,60	14,30	15,10	52.424 €	17.997 €	16.529 €	17.898 €	201.762 €	64.329 €	66.215 €	71.218 €
PRT	2016	74,05	0,64	11,47	3,77	1,18	$ 31.608	$ 26.699	$ 7.354.810.293	1.213.107	1.167.993	38.866	6.248	19,60	25,20	17,20	16,10	56.044 €	19.373 €	17.747 €	18.924 €	210030,9	66186,7	68221,80	75622,50
PRT	2017	76,94	1,56	9,23	5,07	2,89	$ 33.045	$ 26.820	$10.683.844.361	1.259.234	1.212.059	40.547	6.628	20,50	26,10	17,60	17,30	61.318 €	21.541 €	19.366 €	20.411 €	225.486 €	71.100 €	73.423 €	80.963 €
PRT	2018	79,43	1,17	7,17	4,71	-0,22	$ 34.932	$ 27.263	$ 7.846.086.578	1.294.037	1.244.495	42.581	6.961	21,90	29,30	17,00	19,00	65.742 €	23.276 €	20.749 €	21.717 €	238.522 €	74.486 €	77.487 €	86.550 €
PRT	2019	80,94	0,30	6,68	4,27	-0,61	$ 36.945	$ 27.978	$10.332.167.493	1.333.649	1.281.857	44.492	7.300	21,40	29,80	15,90	17,80	69.352 €	23.520 €	22.520 €	23.312 €	248.445 €	78.207 €	81.477 €	88.760 €

Appendix 8: Dataset – Number of SMEs per sector (Portugal)

Source: Appendix 1

Country	Year	Total	Agriculture, farming of animals, hunting, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas and water	Construction	Wholesale and retail trade (...)	Transportation and storage	Accommodation and food service activities	Financial and insurance activities	Real estate activities	Education	Human health and social work activities	Other sectors
PRT	2005	1.150.515	54.956	1.539	86.082	1.280	127.063	279.496	26.018	87.238	30.007	24.969	49.255	66.183	316.429
PRT	2006	1.171.093	56.100	1.495	83.585	1.334	123.013	276.313	25.449	87.777	28.491	25.905	55.460	68.987	337.184
PRT	2007	1.233.432	56.618	1.483	83.561	1.492	125.472	280.118	26.087	89.480	28.430	28.037	60.901	73.720	378.033
PRT	2008	1.260.302	56.710	1.488	81.071	1.727	124.943	276.213	25.914	91.679	25.382	30.060	63.915	79.136	402.064
PRT	2009	1.222.488	55.092	1.421	76.987	1.787	116.585	265.465	25.022	89.867	23.661	30.004	66.662	82.010	387.925
PRT	2010	1.167.168	53.792	1.321	71.982	1.797	105.369	251.273	24.079	85.919	22.806	29.559	65.315	82.877	371.079
PRT	2011	1.135.153	56.554	1.259	70.322	1.924	97.891	243.687	23.671	85.756	22.632	28.976	61.674	83.299	357.508
PRT	2012	1.085.894	56.463	1.173	67.191	2.036	87.527	232.453	22.806	83.820	21.678	28.429	56.793	81.861	343.664
PRT	2013	1.118.427	107.967	1.154	66.128	2.097	81.275	226.476	22.322	82.170	20.975	28.294	55.345	81.508	342.716
PRT	2014	1.146.119	128.757	1.098	65.900	2.142	77.792	221.673	21.800	84.078	18.834	29.557	55.314	83.682	355.492
PRT	2015	1.180.331	133.417	1.062	66.416	2.418	77.851	221.854	21.562	91.780	18.262	32.149	54.616	86.956	371.988
PRT	2016	1.213.107	132.836	1.041	66.632	5.153	78.807	220.173	21.721	97.513	18.043	35.783	54.638	90.703	390.064
PRT	2017	1.259.234	132.915	1.058	67.206	5.226	81.574	218.980	22.757	104.773	17.685	40.786	56.568	94.711	414.995
PRT	2018	1.294.037	132.871	1.018	67.850	5.589	85.256	217.610	25.501	113.135	17.072	45.507	57.884	97.972	426.772
PRT	2019	1.333.649	130.329	1.016	68.453	5.747	90.366	218.206	31.238	117.971	16.610	49.826	58.396	100.969	444.522

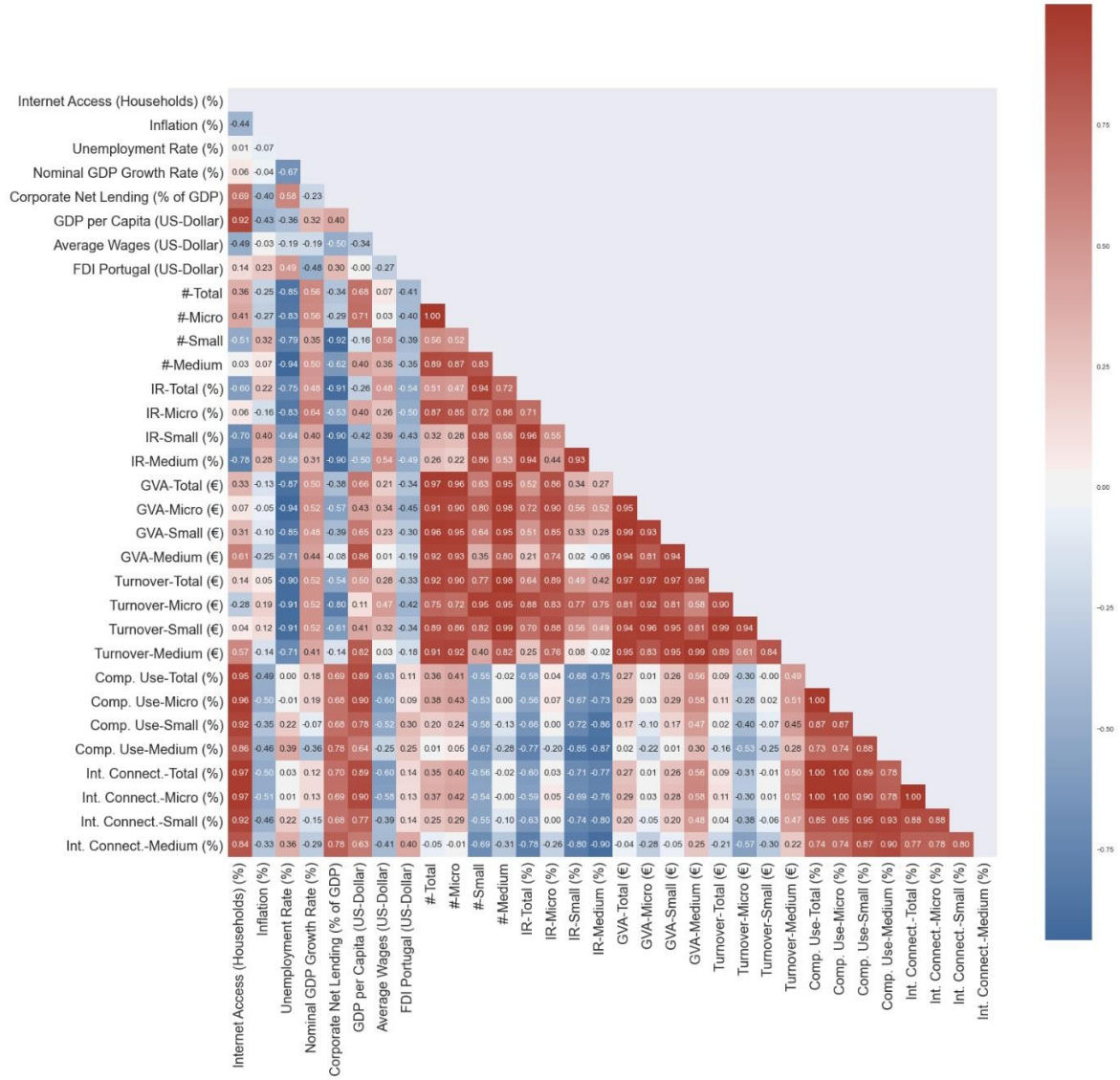
Appendix 9: Dataset – SMEs and ICT related data (Portugal)

Source: Appendix 1

Country	Year	Comp. Use-Total (%)	Comp. Use-Micro (%)	Comp. Use-Small (%)	Comp. Use-Medium (%)	Int. Connect.-Total (%)	Int. Connect.-Micro (%)	Int. Connect.-Small (%)	Int. Connect.-Medium (%)
PRT	2005	60,80	53,10	89,60	99,10	48,10	39,10	78,60	98,10
PRT	2006	61,50	54,00	93,80	99,10	50,00	42,40	80,30	99,10
PRT	2007	67,60	61,20	94,30	99,20	56,30	48,40	88,40	97,80
PRT	2008	70,10	64,50	95,40	99,50	61,20	54,60	90,60	98,90
PRT	2009	66,10	60,40	94,50	99,80	58,80	52,10	91,60	99,20
PRT	2010	67,60	61,70	96,70	100,00	59,40	52,60	93,20	99,60
PRT	2011	71,20	66,20	97,00	100,00	63,50	57,60	94,20	100,00
PRT	2012	78,40	72,20	97,80	100,00	72,70	65,50	94,70	100,00
PRT	2013	83,90	79,80	97,80	100,00	77,20	71,60	95,50	100,00
PRT	2014	88,80	85,70	98,50	100,00	82,80	78,40	95,90	100,00
PRT	2015	89,40	86,30	98,70	100,00	82,90	77,90	97,80	100,00
PRT	2016	90,10	87,20	98,80	100,00	85,00	80,70	97,70	100,00
PRT	2017	90,50	87,70	98,50	100,00	85,70	81,50	97,70	100,00
PRT	2018	91,20	88,40	99,10	100,00	86,40	82,30	98,10	100,00
PRT	2019	96,70	95,60	99,00	100,00	92,50	89,70	97,90	100,00

Appendix 10: Correlation Matrix (Portugal economic data and SME ICT-related data)

Source: Appendix 1



Appendix 11: Correlation Coefficients

Source: Buettgenbach 2021

Size of the correlation coefficient	Interpretation
0.90 to 1.00 (-0.90 to -1.00)	Very high positive (negative) correlation
0.70 to 0.90 (-0.70 to -0.90)	High positive (negative) correlation
0.50 to 0.70 (-0.50 to -0.70)	Moderate positive (negative) correlation
0.30 to 0.50 (-0.30 to -0.50)	Low positive (negative) correlation
0.00 to 0.30 (-0.00 to -0.30)	Negligible correlation

Appendix 12: Connectivity Dimension – Individual indicators

Source: European Commission 2020

Sub-dimension	Description	Individual indicators	Portugal	Denmark	EU-27
Fixed broadband take-up	Take up of overall and ultrafast broadband	Overall fixed broadband take-up	24.6	34.7	27.6
		At least 100 Mbps fixed broadband take-up	27.9	17.1	12.9
Fixed broadband coverage	Availability of fast broadband and of fixed and very high-capacity networks.	Fast broadband NGA coverage	32	27.7	28.6
		Fixed Very high Capacity (VHCN) coverage	55.3	62	29.4
Mobile broadband	Includes 4G coverage, the take-up of mobile broad band, and includes the indicator on 5G readiness.	4G coverage	24	25	24.1
		Mobile Broadband take-up	7.27	16.3	10.7
		5G readiness	4.17	16.7	10.3
Broadband price index	The broadband price of retail offers	Broadband price index	51	60.6	64.22

Appendix 13: GCI - Supply

Source: Huawei 2020

Indicator	Definition
International Internet BandwiDT h	International Internet bandwidth h refers to the total used capacity of international Internet bandwidth h, in megabits per second (Mbit/s). Used international Internet bandwidth h refers to the average traffic load of international fiber-optic cables and radio links for carrying Internet traffic. The average is calculated over the 12-month period of the reference year and takes into consideration the traffic of all international Internet links. International Internet bandwidth h (bit/s) per Internet user is then calculated by converting to bits per second and dividing by the total number of Internet users, and this is used to calculate the index scores. Calculation: per internet user
Telecom investment	Telecom Service Provider investment in modern network infrastructure over an aggregated five-year period. This focuses on key carrier network technologies which are integral to the delivery of cloud, mobile and high-speed data services including service provider routers, service provider switches, and wireless infrastructure (including 3G, 4G and 5G). Aggregate spending over the most recent five-year period is used, in order to provide a more holistic measurement of Telco infrastructure deployments in the context of carrier investment cycles and economic wild cards. Calculation: % of GDP
ICT Laws	A survey on how developed a nation's ICT laws are (e.g. electronic commerce, digital signatures and consumer protection). Calculation: n/a
IoT Investment	Investment on IoT solutions and deployment including systems, sensors, modules, infrastructure, networks, specialized devices, security, software, connectivity services, IT and installation services, content services, OT (operational technology) and ongoing services (including consumer services). Weighed against the size of the population (IoT per capita). Calculation: per capita
ICT Investment	The overall size of the traditional ICT market in each country, as defined by the total amount of end-user spending on IT hardware (servers, storage, PCs, devices, peripherals, network equipment), software, IT services and telecom services. The total market size is measured against the overall size of the economy (GDP), which provides a measurement of market supply maturity. Calculation: % of GDP
4G & 5G Connections	A weighted score of the percentage of mobile device connections which use a 5G connection (accounting for 20% of the score) and the percentage of mobile device connections which use a 4G connection but do not use a 5G connection (accounting for 80% of the score). This measurement is not based on geographic land mass, so it is a more accurate measurement of the actual supply of 4G and 5G services to individuals and organizations. Users who

	have not subscribed to 4G services but who use a 4G phone are not counted; users who have not subscribed to 5G services but use a 5G phone are counted in 4G if they have a 4G connection and are otherwise not counted. Calculation: 80% of 4G connections, 20% of 5G connections
Fiber Optics	The number of Fiber to the Home (FTTH) subscriptions, measured against the total number of households in each nation. "Fiber to the Home" is defined as a communications architecture in which the final connection to the subscriber's property is Optical Fiber. The fiber optic communications path is terminated on or in the premise for the purpose of carrying communications to the subscriber. Calculation: % of total households
Security Software Investment	Investment in software related to the security of ICT resources and data. These security products may be deployed in data centers, on networks, and on devices. Spending by all end-user segments is included (private and public sector). The data is weighted by the total size of the population. Calculation: per capita
AI Investment	The sum of investments for the deployment of AI solutions by private and public institutions. This includes AI-related investments in hardware systems, software platforms and professional services. Calculation: % of GDP
Cloud Investment	Overall investment in public cloud infrastructure services (Infrastructure as a Service), leveraged for the supply of server (compute) and storage infrastructure resources in a public cloud environment. This provides a direct measurement of the supply of services from public cloud infrastructure deployments to end-users. It is weighted against GDP. Calculation: % of GDP

Appendix 14: GCI - Demand

Source: (Huawei 2020)

Indicator	Description
Fixed Broadband Subscriptions	Total number of subscriptions that access the internet through a wireline (including satellite) broadband internet connections. Calculation: per capita
Mobile Broadband Subscription	Total number of mobile broadband services subscribers measured in relation to the overall size of the population. Calculation: per capita
Smartphone Penetration	Smartphone penetration expressed as a percentage of total connections (excluding M2M). A smartphone is defined as a mobile handset with advanced access to internet-based services and computing functions. Calculation: % of total connections
App Downloads	The total number of new mobile application downloads in the calendar year on all major mobile platforms (including all Android and

	iOS). This is measured against the overall size of the population, and refers to new app downloads, not the existing installed base. Calculation: per capita
E-commerce Transactions	E-commerce involves orders placed on the internet (i.e., the buyer clicks an order button on the internet) in a commitment for paid goods or services. Total E-commerce measures the volume of all E-commerce transactions, both B2B and B2C (including volume purchases). Calculation: per capita
Cloud Migration	An index based on the percentage of traditional software budgets which have migrated from traditional on-premise licensing to 'as a service' cloud deployments, in order to measure demand for advanced Public Cloud Services in relation to overall ICT investment. Calculation: % of total annual software investment
AI Demand	The percent of third-party software spending and investment that is on AI software in a country. Calculation: % of total annual software investment
IoT Installed Base	Total installed base of IoT devices and systems (including Intelligent Systems). Calculation: per capit
Secure Internet Servers	Secure Internet Servers (per 1 million people) refers to the number of distinct, publicly-trusted TLS/SSL certificates according to the Netcraft Secure Server Survey. Calculation: per capita
Computer Households	The number of households with access to a computer – a fixed desktop computer, laptop, or Tablet (or similar handheld computer). Excludes smartphones. Calculation: % of total households

Appendix 15: GCI-Experience

Source: (Huawei 2020)

Indicator	Description
Fixed Broadband Affordability	The price of a monthly subscription to an entry-level fixed broadband plan of a minimum of 5 GB. For plans that limit the monthly amount of data transferred by including data volume caps below 5 GB, the cost for the additional bytes is added to the basket. The minimum speed of a broadband connection is 256 kbit/s. The calculation is a percentage of a nation's average monthly GNI per capita. Calculation: per GN
Mobile Broadband Affordability	The price of a monthly subscription to prepaid and postpaid data services across a variety of service plans and device types. Up to 2017, prices are for 1 GB of data for a USB/ dongle, computer-based subscription. 2018 onwards it is mapped to the 1.5 GB subscription, irrespective of the device used. This is calculated as a percentage of a nation's average monthly GNI per capita. Calculation: per GNI
Broadband Download Speed	Average download speed for each country. These metrics leverage billions of Internet and mobile network tests to provide a current view and analysis of global Internet access speeds. Calculation: n/a
Cybersecurity Awareness	The Global Cybersecurity Index is a trusted reference that measures the commitment of countries to cybersecurity at a global level. As cybersecurity has a broad field of application, cutting across many industries and various sectors, each country's level of development or engagement is assessed along five categories: Legal Measures, Technical Measures, Organizational Measures, Capacity Building and Cooperation; and then aggregated into an overall score. Scores are derived from an online survey, which also allowed for the collection of supporting evidence. Through consultation with experts, these survey responses were then weighted in order to arrive at the final index scores. Calculation: n/a
Telecom Customer Service	Current service levels provided by telecom operators based on previous research and

	surveys conducted within each nation. Calculation: n/a
Internet Participation	The total number of individuals accessing the internet at least once during the 12-month period, via wireline and/or mobile internet access. Calculation: per capita
E-Government Service	These scores are sourced directly from the United Nations E-Government Survey, which benchmarks countries according to ratings derived from a survey to assess the E-government development status of all UN member states. Calculation: n/a
IoT Analytics	Total investment on analytics software relating to IoT data analysis. These software tools that extract value from the mass of data being created via IoT to improve the experience of a nation or organization with an IoT platform that transforms IoT data into actionable information. Calculation: per capita
Data Creation	Based on the estimated availability of target-rich, actionable data (TB) which can be leveraged by AI platform and analytics tools in order to enhance the experience and ROI of organizations investing in the deployment of AI solutions. To improve the experience of this technology, the scalability of created data needs to be considered. Calculation: TB per capita
Cloud Experience	The percent of total IT investment within a country that is by cloud service providers. Calculation: % of IT investment

Appendix 16: GCI-Potential

Source: (Huawei 2020)

Indicator	Description
ICT Patents	The total number of patents filed under the PCT within the ICT technology domain in the inventor's country of residence, as measured and tracked by the OECD (stats. oecd.org). Calculation: per capita
IT Workforce	Total employment in the supply and management of IT for each nation. This includes workers employed directly in the IT industry (hardware manufacturers, software vendors, service providers and channel organizations), and IT staff employed by end-users in IT departments for the management, deployment, support, and strategic implementation of technology solutions. Calculation: per capita
R&D Expenditure	Expenditure on R&D means current public and private capital expenditure on creative work to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development. Calculation: % of GDP
Software Developers	The total number of software developers in each nation. Professional software developers are engaged in employment where the primary activity is constructing software or supervising its construction. Calculation: per capita
ICT Market Potential	An index derived from local nation survey data on the potential for market development and the economic benefits to be derived from adoption of adopting Cloud, AI, IoT and Broadband solutions. In order to assess future potential for development, the five-year forecasted CAGR (compound annual growth rate) is used for the time period through 2025. This CAGR accounts for current market assumptions relating to technological development, penetration rates, macroeconomic growth and the ability of customers in each country to invest in these ICT markets. Calculation: n/a
ICT Influencing New Business Model	Based on a survey conducted by the World Economic Forum, in which respondents

	were asked to evaluate the extent to which ICTs enable new business models. Calculation: n/a

Appendix 17: Corporate and Entrepreneurial innovation

Source: (IAPMEI 2020a, 2020b; ePortugal.gov.pt 2021)

System	Target	Description
SI Qualified and Creative Entrepreneurship	SME in operations for less than 2 years	Support system that includes a non-repayable incentive component
SI Productive Innovation	Companies of any kind or legal form	Aims to promote business innovation in: Production of new goods and services Adoption of new or significantly improved manufacturing-, logistic-, distribution- or organizational processes and methods.

Appendix 18: SME Qualification and Internationalization

Source: (ePortugal.gov.pt 2021; IAPMEI 2020c, 2020d)

System	Target	Description
SI Qualification – individual project	SME of any kind of legal form	Individual project to strengthen the business capability of SMEs through organizational innovation, applying new methods and organizational processes.
SI Qualification – joint project-	Not-for-profit entities with specific expertise targeted at SMEs	Joint project to strengthen the business capability of SMEs through organizational innovation, applying new methods and organizational processes.

Appendix 19: Research and technological development

Source: (ePortugal.gov.pt 2021)

System	Target	Description
SI R&D Companies	Companies with any kind of legal form	Supporting R&D in companies and its economic development to increase cooperative projects and activities of companies to develop new products and services, focusing on higher technology and knowledge.
SI R&D Centers	Companies with any kind of legal form	Supports developing new products and services, especially in activities with greater technological and knowledge intensity. Aiming to prompt R&D with companies and other entities.
IS Industrial Property	Companies with any kind of legal form	R&D projects, aimed at promoting registration of industrial property rights in the form of registration of patents, utility models, designs, national and internationally

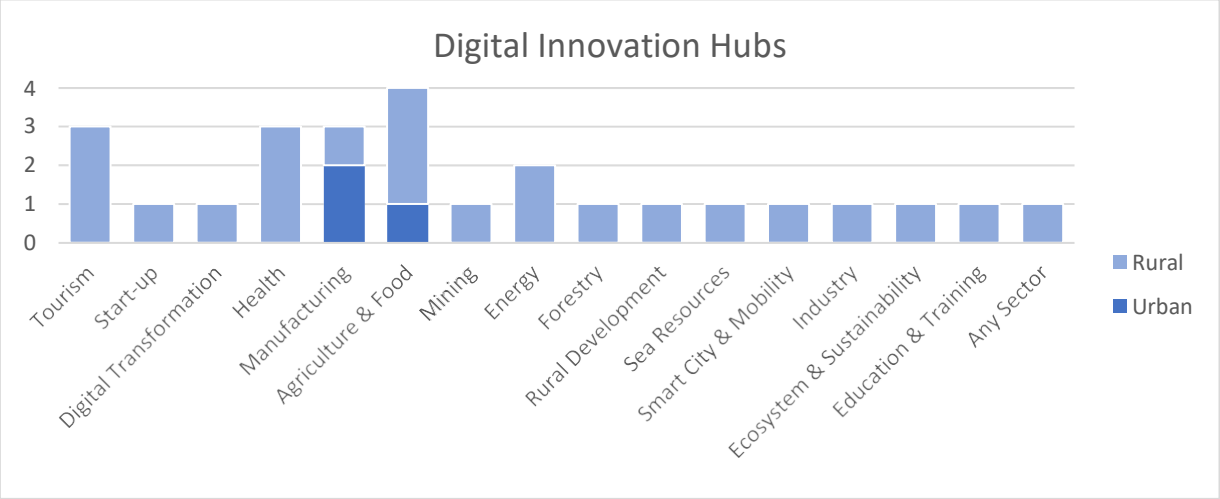
Appendix 20: Digital Innovation Hubs Criteria

Source: (European Commission 2021b)

Criteria
Part of a regional, national, or EU policy initiative that focuses on digitizing the industry
Being a non-for-profit organization
Physical presence in the region the DIH states, an updated website which communicates the DIHs' activities and services related to the digital transformation of SMEs or of industrial sectors that currently underutilize digital technologies
Representing at least 3 examples of how the DIH supported the DT of a company.

Appendix 21: Digital Innovation Hubs

Source: (European Commission 2021b)



Appendix 22: Digital Innovation Hubs Portugal

Source: (European Commission 2021b)

DIH	Location	Description	Focus Area
Algarve Smart Destination, DIH	Faro		Tourism
Azores Digital Innovation Hub	Lagoa	One-stop shop for DT	Tourism and Sustainability
CONNECT 5	Aveiro Region	Gathering main national players in Information, Communication and Electronic Technologies	Digital Transformation, Start-up acceleration
DIAMOTIC Health	Coimbra	Access to knowledge, development to boost innovative product design in personal health and wellbeing	Life science & healthcare
HUB for Agriculture	Lisbon	Initiative to create a multi-sector cooperation network that promotes the connection between the technology provider and the needs of the agricultural sector	Agriculture and food
iMan Norte Hub – Digital Innovation Hub for Customer-Driven Manufacturing @ Norte	Porto	Fostering digital transformation of manufacturing companies in the northern region	Manufacturing
inNOVA4TECH hub – innovation Hub for TECHnology Transfer	Caparica	Supporting Digital Transformation of companies (SME and mid-caps) with a wide range of advanced technologies	Agriculture and food, Mining and quarrying, energy and utilities, Construction, Life sciences & healthcare, Manufacturing
INSTITUTO NACIONAL DE INVESTIGACAO AGRARIA E VETERANIA	Oeiras	Performing research activities in the field of agronomy and veterinary medicine.	Agriculture, forestry, and rural development
Madeira Digital Innovation Hub	Funchal	Developing a variety of activities, a wide	Tourism, Sea resources, and technology, agri-

		range of business services, including	food, smart city and mobility, industry, Energy and water efficiency, Ecosystem and sustainability, Healthcare, Education and Training
NOVA ID FCT – ASSOCIACAO PARA A INVOVACAO E DESENVOLVIMENTO DA FCT	Caparica	Supporting culture of Research Excellence & Innovation, Strengthening the link between industry needs and societal challenges	Potential innovation HUB from Horizon 2020 Programme
PRODUTECH Digital Innovation Hub National Platform	Porto	Fostering digital transformation in manufacturing companies	Manufacturing industry
PTCentroDiH Digital Innovation Hub da Regiao Centro	Marinha	Modernizing industries through digital transformation	SMEs of any sector
SIH – Smart Island Hub	Funchal	Promote Innovation using the islands as a living lab for "testing and learning", Digital Transformation towards sustainable development.	Start-up, SMEs, Mid-caps
UNINOVA-INSTITUTO DE DESENVOLVIMENTO DE NOVAS TECHNOLOGIAS-ASSOCIACAO	Caparica	Supporting culture of Research Excellence & Innovation, Strengthening the link between industry needs and societal challenges	Potential innovation HUB from Horizon 2020 Programme

Appendix 23: Potential European Digital Innovation Hubs

Source: European Commission 2021a

Potential EDIH	Location	Technology	Focus Area
AI4PA Portugal	Lisbon	AI, Data Science, and Big Data, Qualification in advanced digital skills, High-performance computing, digital solutions/ interoperability for public sector	Public Administration, All sectors, Communication, and electronic information technologies, Circular economy environment and sustainability, mobility and logistics
Apollo Health	Caparica	AI Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public sector Additive manufacturing Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Advanced materials Nanotechnology Micro/Nano Electronics Photonics Simulation Cyberphysical systems Blockchain Cloud computing Mobility Connectivity Sectors	Public Administration, Communication and electronic Information Technologies, Health and Biotechnology
ATTRACT DIH	Porto	AI; High-performance computing; Data Science and Big Data; Digital solutions / interoperability for the public sector Sectors, Qualification in advanced digital skills Digital solutions	Horizontal (all sectors)
Azores Digital Innovation Hub (AzDIH)	Lagoa	AI High-performance computing Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public sector	Industry Agriculture Public Administration Circular economy, environment and sustainability Tourism Culture Mobility and logistics Communication and electronic Information Technologies Energy Natural

		Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Advanced Materials Micro/Nano Electronics Simulation Blockchain Cloud computing Mobility	Resources and extractive industry Ocean and fisheries
C-Hub: Cybersecurity DIH	Lisbon	Cybersecurity Digital solutions/interoperability for the public sector Internet of Things Simulation Cyber-Physical systems Blockchain	Horizontal (all sectors)
connectAHEAD Aerospace, eHealth, and Digital Critical Technologies	Evora	AI High-performance computing Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public sector Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Advanced materials Simulation Cloud computing Mobility Connectivity Sectors:, Industry Agriculture Public Administration Tourism Telecommunications Mobility and logistics Communication and electronic Information Technologies Health and Biotechnology Energy Trade and Services Other Sectors (aerospace)	Aerospace, health, and critical digital technologies
CONNECT5	Îlhavo	AI High-performance computing Cybersecurity Qualification in advanced digital skills Digital	Public administration, Education, Community, social and personal service activities, Manufacture of electrical and optical equipment, Mobility (incl.

		solutions/interoperability for the public sector Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Micro/Nano Electronics Photonics Simulation Cyberphysical systems Blockchain Cloud computing	Automotive), Telecommunications, Information and Communication
Defence4Tech Hub	Lisbon	AI High-performance computing Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public sector Additive manufacturing Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Advanced materials Nanotechnology Micro/Nano Electronics Photonics Simulation Cyberphysical systems Blockchain Cloud computing	Industry Agriculture Construction Public Administration Circular economy, environment, and sustainability Telecommunications Mobility and logistics Communication and electronic Information Technologies Health and Biotechnology Energy Trade and Services Natural Resources and extractive industry Sea and fisheries Forest
DigiHealthPT	Maia	AI High-performance computing Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public sector Additive manufacturing Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Advanced materials Nanotechnology Micro/Nano Electronics Photonics Simulation Cyberphysical systems	Industry Public Administration Circular economy, environment, and sustainability Communication and electronic Information Technologies Health and Biotechnology

		Blockchain Cloud computing	
Dig_In4.0 - Polo de Inovação Digital para o Desenvolvimento e Aceleração da Indústria 4.0	Amadora	AI High-performance computing Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public sector Additive manufacturing Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Advanced materials Nanotechnology Photonics Simulation Cyberphysical systems Blockchain Cloud computing	Industry Public Administration Energy
DIGITALbuilt	Porto	AI, High-performance computing, Cybersecurity, Qualification in advanced digital skills, Additive Manufacturing, Virtual and augmented reality, Internet of Things, Data Science and Big Data, Advanced Materials, Micro/Nano Electronics, Simulation, Cyber-Physical systems, Blockchain, Cloud computing	Industry, Construction, Public Administration, Circular economy, environment and sustainability, Telecommunications, Mobility and logistics, Communication and electronic information technologies, Natural Resources, and extractive industry.
DIH 4 Global Automotive	Matosinhos	AI Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public sector Additive manufacturing Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Advanced materials Micro/Nano Electronics	Manufacture of textiles and textile products, Manufacture of rubber and plastic products, Manufacture of basic metals and fabricated metal products, Manufacture of machinery and equipment, Manufacture of electrical and optical equipment, Manufacture of transport equipment, Mobility (incl. Automotive)

		Simulation Cyberphysical systems Blockchain	
DIH4ClimateNeutrality	Caracavelos	Data Science and Big Data/AI/ High-performance computing /Cybersecurity/ Qualification in advanced digital skills/ Digital solutions - interoperability for the public sector/ Cloud Computing.	Industry; Public administration; Circular economy, environment, and sustainability; Telecommunications; Financial sector; Mobility and logistics; Information technologies, communication, and electronics; Energy.
DIH4Sm@rtRegions	Braganca	AI High-performance computing Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public sector Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Micro/Nano Electronics Simulation Cyber-Physical systems Blockchain Cloud computing	Industry Agriculture Public Administration Circular economy, environment and sustainability Tourism Culture Mobility and logistics Communication and electronic Information Technologies Energy Commerce and Services Forest
DSAI – PMC - DATA SCIENCE & AI PREDICTION MODELS CENTER	Lisbon	Digital solutions/interoperability for the public sector, Data Science and Big Data, Simulation, Cloud Computing	Horizontal (all sectors)
D2P2 - Data-Driven Public Policy Innovation Hub	Lisbon	Qualification in advanced digital skills, Data Science and Big Data, Cloud computing	Public Administration
EUROPE (RE)S+T+ARTS	Aveiro	AI High-performance computing Qualification in	Horizontal (all sectors)

		advanced digital skills Virtual and augmented reality Internet of Things Data Science and Big Data Micro/Nano Electronics Simulation Cyber-Physical systems Blockchain Cloud computing	
Future Cities DIH	Leca da Palmeira	AI Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public sector Additive manufacturing Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Advanced materials Simulation Cyberphysical systems Blockchain Cloud computing, Mobility, Connectivity	Industry Construction Public Administration Circular economy, environment, and sustainability Culture Mobility and logistics Communication and electronic Information Technologies Health and Biotechnology Energy Trade and Services Other Sectors (Territories and Cities)
Hubility - Sociodigital Innovation Hub for Enhanced Capabilities in the Public Sector / Polo de Inovação Sociodigital para o Reforço de Competências no Sector Público	Lisbon	AI, High-performance computing, Cybersecurity, Qualification in advanced digital skills, Digital solutions/interoperability for the public sector, Robotics, Virtual and augmented reality, Internet of Things, Data Science and Big Data, Photonics, Simulation, Blockchain, Cloud Computing, Mobility, Connectivity	Industry, Public Administration, Tourism, Culture, Trade, and Services

InnovTourism	Covilha	AI, High-performance computing, Cybersecurity, Qualification in advanced digital skills, Virtual and augmented reality, Internet of Things, Data Science and Big Data, Blockchain, Cloud Computing, Mobility, Connectivity	Public Administration, Tourism, Financial sector, Communication, and electronic Information Technologies, Trade and Services.
iNOVelectron	Custóias Porto	AI Digital solutions/interoperability for the public sector Additive manufacturing Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Advanced materials Nanotechnology Micro/Nano Electronics Photonics Simulation Cyberphysical systems Mobility Connectivity	Industry Telecommunications Energy Trade and Services
Portugal Blue Digital Hub	Leca da Palmeira	AI, Qualification in advanced digital skills, Robotics, Virtual and augmented reality, Internet of Things, Data Science and Big Data, Simulation, Cloud Computing, Connectivity	Circular economy, environment and sustainability, Tourism, Mobility and logistics, Communication and electronic Information Technologies, Health and Biotechnology, Energy, Sea, and fisheries
PRODUTECH DIH	Porto	AI High-performance Computing Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public	Industry

		sector Additive manufacturing Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Advanced materials Nanotechnology Micro/Nano Electronics Photonics Simulation Cyberphysical systems Blockchain Cloud computing Mobility Connectivity Sectors	
PTcentroDiH - Digital Innovation Hub da Região Centro	Marinha Grande	Micro/nano electronics Sensory systems Photonics and imaging technologies Communication networks Cyber-physical systems Robotics Internet of things AI Mobility & Location-based technologies Interaction technologies Cyber security Advanced, or high-performance computing Big data, data analytics, data handling Simulation, modeling, and digital twins Software as a service and service architectures Cloud computing Additive manufacturing	Construction, Manufacture of food products, beverages, and tobacco, Manufacture of textiles and textile products, Manufacture of leather and leather products, Manufacture of wood and wood products, Manufacture of pulp, paper, and paper products; publishing and printing, Manufacture of coke, refined petroleum products, and nuclear fuel, Manufacture of chemicals, chemical products, and man-made fibers, Manufacture of rubber and plastic products, Manufacture of other non-metallic mineral products, Manufacture of basic metals and fabricated metal products, Manufacture of machinery and equipment, Manufacture of electrical and optical equipment, Manufacture of transport equipment, Other Manufacturing

		Laser-based manufacturing Logistics Internet services New media technologies Nanotechnology	
PT.DigMaking.IH	Coimbra	Qualification in advanced digital skills Additive manufacturing Robotics Virtual and augmented reality Internet of Things Advanced materials Micro/Nano Electronics Connectivity	Industry Agriculture Public Administration Circular economy, environment and sustainability Tourism Culture Mobility and logistics Communication and electronic Information Technologies Energy Trade and Services Natural Resources and extractive industry Forest Horizontal (all sectors)
SFDIH	Torres Vedras	AI Cybersecurity Qualification in advanced digital skills Digital solutions/interoperability for the public sector Robotics Virtual and augmented reality Internet of Things Data Science and Big Data Blockchain Cloud computing Connectivity	Agriculture Circular economy, environment and sustainability
SIH – Smart Islands Hub	Funchal	Robotics Internet of things AI Interaction technologies Cyber security Advanced, or high-performance computing Big data, data analytics, data handling Cloud computing Additive manufacturing Logistics	Energy and utilities Transport and logistics Public administration Life sciences & healthcare Environment Professional, Scientific, and Technical Activities Telecommunications, Information, and Communication
Smart Sustainable Farms Foods and	Lisbon	AI; Internet of things; Data science and big	Agriculture; Industry; Mobility and logistics; Circular

Trade European Digital Innovation Hub (SFT-EDIH)		data; Blockchain; Photonics; Robotics; Virtual and augmented reality	economy, environment, and sustainability

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