Politecnico di Milano

MASTER IN MANAGEMENT ENGINEERING

An Empirical Approach for Measuring and Improving the Digital Maturity of the EU Member States

Master Thesis

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List of Abbreviations

AI	Artificial Intelligence
B2B	Business-to-Business
B2C	Business-to-Customer
B2G	Business-to-Government
CI	Composite Index
CRM	Customer Relationship Management
DAS	Digital Agenda Key Indicators
DESI	Digital Economy and Society Index
DMI	Digital Maturity Index
EDI	Electronic Data Interchange
EHR	Electronic Health Record
ERP	Enterprise Resource Planning
GDP	Gross Domestic Product
ICT	Information and Communication Technology
IPv6	Internet Protocol Version 6
JRC	Joint Research Center
KPI	Key Performance Indicator
LTE	Long Term Evolution
MFP	Multi-Factor Productivity
MOOC	Massive Open Online Courses
OECD	Organization For Economic Co-Operation And Development
R&D	Research and Development
SME	Small and Medium-sized Enterprise
UMTS	Universal Mobile Telecommunications System
Wi-Fi	Wireless Fidelity

0. Executive Summary

About two centuries ago, the world has seen one of the most influential development in history. The Industrial revolution. It changed whole industries and the way how people worked. Currently, we are amidst another, similar revolution: the rise of Information and Communication Technologies (ICT). Even though ICT has been around us for quite some time, it is only recently that governments and state leaders bump this topic up on their agendas and priority lists. For instance, in the recent signed coalition agreement between the two ruling parties in Germany, digitization was one of the key areas focused, some even called for the creation of a new ministry, the digital ministry. The reason why digitization plays such as crucial role nowadays, is because state leaders have realized its potential. Most of the "Productivity Miracle" which describes the skyrocketing productivity growth experienced in the US throughout the 90s, is ascribed to the large investment made in ICT and unerring nurturing of ICT education. It is no wonder that the top 10 of the largest companies[1] by market capitalization consists of seven tech companies (five headquartered in the US, remaining two in China). Policy makers in Europe jumped late on the bandwagon but are boosting digitization heavily in recent years. As a consequence, each country has its own digital agenda now, where digital initiatives and visions are stated and explained. In addition, the European Commission has its own digital agenda, aiming for a "digital single market in order to generate smart, sustainable and inclusive growth in Europe". In addition, the European Commission created a composite index, the Digital Economy and Society Index" (DESI) to measure the digital performance of all its member states. While this is the current situation, some challenges emerged that triggered the creation of this thesis.

The objectives, or at least some part the priorities of the European digital agenda do not necessarily align with the objective of every single state. Thus, state leaders must identify their own agenda and spot the right areas that need the most improvements. This is a difficult undertaking as every state has its own strengths and weaknesses. Decision makers can use DESI as a benchmark and to assess how their state fares against other EU members. But the results of DESI have to be taken with a grain of salt. DESI includes only 31 indicators, excluding highly relevant ICT areas such as eHealth, ICT innovation or ICT policies. This finding is backed by the Organization for Economic Co-operation and Development (OECD), that calls for a new statistical framework which takes into account the dynamic and ubiquitous

[1] As of 31.03.2018

nature of ICT. As a consequence, the first objective of this thesis is to find a better way to measure the digital performance of a country.

Moreover, current benchmarks, such as DESI, do provide little insights on which initiatives led to the performance measured, providing state leaders only little guidance for their own agenda. What state leader actually need are tools and methods to identify the right initiatives for their own country, considering its current performance, financial resources, jurisdictions, etc. It does not always make sense for a low performing country to orientate on best practices from high performing countries, as they foundations might differ. For instance, it could make more sense to follow best practices from other countries that managed to improve its digital performance faster than others. A more flexible approach is required instead of ranking 28 countries. Hence, the second objective of this thesis is to provide state leaders with better, tailored, and more informed guidelines that will allow them to improve their digital maturity in an efficient and sustainable fashion. The following two research questions has been compiled:

I. How can the digital maturity of a country be measured in order to provide policy makers with profound, comprehensive insights for increasing it?
II. What are features of a digital high / low performer? Countries that improved / worsen their digital performance, which were the relevant factors for the advancement / decline? Are there common patterns so that several countries pursue a similar digital development?

In order to answer the first question, it was necessary to understand the whole impact of ICT for a nation. Consequently, an extensive literature analysis was composed to identify all main stakeholder of a society that are affected through ICT. Applying an economical perspective, Citizen, Firms and Public Administrations are identified as main actors, connected through Infrastructure that enables digital interactions. Subsequently, ICT's impact on each actor is delineated, emphasizing the omnipresent role of ICT. This comprehensive view has not been applied before, thus no index or other type of benchmark exists that considers this broad swath of factors. Based on the four dimensions identified (Citizen, Firm, Public Administration and Infrastructure) a new composite index was created, named "Digital Maturity Index" (DMI). Each domain of the DMI consists of two sub-categories that show the correlations between enabling factors and achieved results. This separation allows users to narrow down the

measures that eventually led to the performance leap. Figure 1 shows a graphical illustration of the DMI framework, its domains (black boxes) and sub-categories (white boxes).

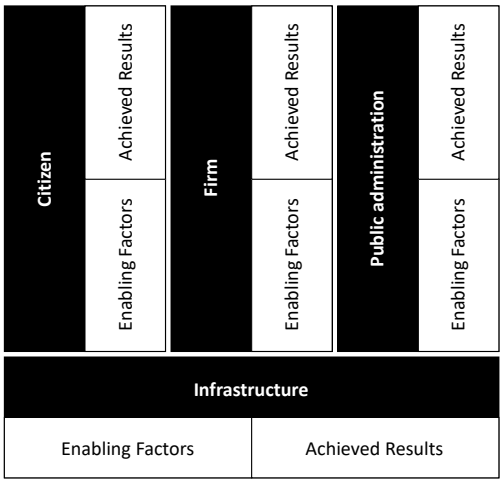


Figure 1: Theoretical Framework of DMI

The design of the whole index was guided by insights drawn from literature and formulated in six hypotheses (see Table 1). After the hypotheses have been verified, the DMI was used to answer the second research question. As a first step, countries were grouped into three clusters according to their performance. The grouping has been done for two time periods with 4 years distance between the two periods (2012 & 2016). In the second step, the created clusters were checked whether each cluster is significantly different than the other cluster to ensure the reliability of the findings. Furthermore, the clusters were correlated with outside variables, such as DESI or GDP. In a third and final step, the clusters of the two time periods were compared with each other, highlighting countries that moved up or down between clusters. Eventually, the performance improvement or decline of all countries was analyzed to spot common patterns, extracting valuable insights for decision makers regarding key success factors to improve a country's digital performance.

A plethora of statistical methods was used to evaluate the validity of the design and results of the DMI. First all indicators have been standardized to ensure the data is one the same scale. Through a factor analysis (including Cronbach alpha test), factors have been created that included all indicators representing the sub-categories of each domain. The validity of the hypotheses was assessed through a panel data analysis, also called longitudinal analysis (including the Hausman test to select between fixed or random effect model). A hypothesis is supported when a significant correlation between independent and dependent variable exists, shown through a p-value lower than 0.1. The analysis found in five out of the six hypothesis a significant correlation (see Table 1). It is assumed that the one rejected hypothesis is due to low data availability for the corresponding domain.

Table 1: Results of Panel Data analysis

Hypothesis	Description	Independent Variable	Dependent Variable	P-value
1	*Progress in Citizen Enabling Factors does influence positively the Achieved Results within the Citizen domain*	Citizen Enablers	Citizen Achieved Results	0.007
2	*Progress in Firm Enabling Factors does influence positively the Achieved Results within the Firm domain*	Firm Enablers	Firm Achieved Results	0.007
3	*Progress in Public Administration Enabling Factors does influence positively the Achieved Results within the Public Administration domain*	Public Administration Enablers	Public Administration Achieved Results	0.603
4	*Progress in Infrastructure Enabling Factors does influence positively the Achieved Results within the Infrastructure domain*	Infrastructure Enablers	Infrastructure Achieved Results	0.040
5	*Progress in Public Administration Enabling Factors does influence positively the Achieved Results within the Citizen domain*	Public Administration Enablers	Citizen Achieved Results	0.032
6	*Progress in Public Administration Achieved Results does influence positively the Achieved Results within the Firm domain*	Public Administration Achieved Results	Firm Achieved Results	0.035

The grouping of countries was performed through a two-step clustering. The first step used hierarchical clustering to select the number of cluster, obtaining three clusters for both periods. The second step applied the k-means method to cluster the countries. Then, a one-way analysis of variance (ANOVA) test was performed to evaluate differences between the mean values of the identified clusters, using Scheffé's multiple-comparison test. The same test was used to compare the DMI clusters with outside variables, such as DESI and GDP. For both time periods, the three clusters obtained were significantly different. In addition, the second test found out that DMI clusters are able to predict a country's position in the DESI. This means, countries that perform low in the DMI tend to receive low DESI scores, while high performing countries measured through the DMI tend to receive high scores in DESI. This correlation was not found consistently when comparing DMI clusters with GDP. Table 2 shows the final clusters obtained in 2016, separating the clusters in low, middle and high performing countries.

Table 2: Final Results Cluster Analysis

2016								
Cluster	Countries	Category	Obs.	*Diff.*	Mean	Std. Dev.	Min	Max
Cluster High	Belgium(+), Germany(+), Luxembourg(=), France(+), United Kingdom(=), Estonia(+), Finland(=), Netherlands(=), Sweden(=), Austria(+), Denmark(=)	C_Achieved_Z	11	*5*	0.9232	0.6948	0.0000	1.8361
		F_Achieved_Z	11	*5*	0.8295	0.6774	0.0000	1.8014
		I_Achieved_Z	11	*5*	0.9403	0.5818	-0.0933	1.7286
		P_Achieved_Z	11	*5*	0.9313	0.4978	0.2537	1.6993
Cluster Middle	Poland(+), Malta(=), Czech Republic(+), Slovakia(+), Spain(=), Italy(+), Portugal(+), Cyprus(+), Latvia(+), Croatia(+), Hungary(+), Lituania(+), Slovenia(=)	C_Achieved_Z	13	*4*	-0.3945	0.3673	-1.2175	0.0477
		F_Achieved_Z	13	*4*	-0.4424	0.4315	-1.0786	0.3064
		I_Achieved_Z	13	*4*	-0.4512	0.4602	-0.9507	0.3709
		P_Achieved_Z	13	*4*	-0.4026	0.5618	-1.2896	0.2782
Cluster Low	Greece(=), Romanio(=), Bulgaria(=)	C_Achieved_Z	3	*-10*	-1.6607	0.6597	-2.0664	-0.8994
		F_Achieved_Z	3	*-10*	-1.5343	0.2610	-1.7692	-1.2533
		I_Achieved_Z	3	*-10*	-1.7258	0.4655	-2.2328	-1.3177
		P_Achieved_Z	3	*-10*	-1.6044	0.3928	-2.0505	-1.3101

Note:

C_Achieved_Z = standardized values of Citizen Achieved Results, F_Achieved_Z = standardized values of Fitizen Achieved Results

I_Achieved_Z = standardized values of Infrastructure Achieved Results, P_Achieved_Z = standardized values of Public Adminstration Achieved Results

(+) = moved up one cluster, (-) moved down one cluster, (=) remained same cluster

Concerning the first objective it this thesis, a new composite index was developed, that represents a powerful tool to measure the digital maturity of a country and allows policy makers and state leaders to gain profound insights on their countries performance. The correlation stated and validated between Enabling factors and Achieved results provides rich guidance on how to improve certain areas of ICT. In comparison to existing benchmarks, such as DESI's 31 indicators, DMI consists of 179 indicators. Through the comprehensiveness of this index, decision makers are enabled to not only make better, but also more informed decisions.

Regarding the second objective, the main feature identified for both low and high performing countries was a homogenous performance in all dimensions. Furthermore, high performers showed little advancements throughout the four years measured, implying that once a country set the bar it is harder and / or costlier to improve even further. Opposite to that, it is easier and / or cheaper for following countries to close the gap, explaining the vast upward movements. That said, low performing countries did perform low in all four dimensions and countries from the middle cluster tend to perform mediocre in all dimensions, conforming the homogenous behavior mentioned before.

As a consequence of the observed homogeneity, it was not possible to determine one factor that is more relevant over others. However, it was detected that some countries, if unbalanced, showed larger improvements in weak performing area, leveling the overall performance this way. Thus, the observed common pattern is a homogeneous digital performance of most of the countries and a sort of leveling effect for countries that showed uneven results in one of the dimensions.

In conclusion, the findings of this thesis suggest that a more holistic approach is necessary for state leaders and policy maker, when the objective is to improve the digital performance of their country. Quick wins seem to be possible, if one domain of a country shows substantial weaker results, than the remaining domains. The DMI represents a helpful assistant in measuring the digital performance comprehensively and enables state leader to identify strengths and weaknesses of their country and their peers.

1. Introduction

Information and Communications Technologies (ICT) play an ever-growing part within our society, hence it is no wonder that policy-makers bump this topic up on their agendas and priority lists. The European commission states, "One digital market: Bringing down barriers to unlock opportunities" as one of their top 10 priorities to work on from 2015-2019. State leaders realized that ICT can be used as vehicle to achieve other more traditional governmental goals, such as reducing unemployment rate or stimulating the country's economy. For instance, the UK's digital economy - including start-ups as well as tech behemoths like Apple - grew 32pc faster than the rest of the economy between 2011 and 2014, creating more than 150,000 new jobs within those three years (Burn-Callander, 2016). Literature has long acknowledged that progress in ICT will eventually lead to economic growth of a nation (Wang, 1999, Vu, 2011, Colecchia and Schreyer, 2002). While the general importance of ICT seems to be understood, until today there is little consensus on which ICT areas should one country focuses the most. Researchers admonished to not blindly copy successful strategies of other countries, but tailor the ICT strategy of a nation to its specific needs (Avgerou, 2003, Bloom et al., 2012).

Today, most of the EU countries have ICT on their political agenda and dedicate a significant amount of their budget in the improvement of their digital economy, IT infrastructure or digital policies. In fact, each country develops their own digital Agenda focusing on what state leaders deem to be important. Consequently, the amount of ICT spending differs as much as ICT priorities for each country.

As a reference point, Germany spent over 470 million Euros for the development of its digital infrastructure solely in 2017 (Infrastruktur, 2017). As there are plenty of areas to invest in (e.g. broadband infrastructure, digital governmental services, innovation, etc.), states develop digital agendas, roadmaps listing future measures and investments for all ICT related fields. On top of that is the European commission's own digital agenda with its main objective of developing “a digital single market in order to generate smart, sustainable and inclusive growth in Europe" (Commission, 2015b). Further, the commission developed the "Digital scoreboard", allowing to quantify the performance of Europe and its member states in several technological disciplines as well as to benchmark them (Commission, 2015a). The most established index is the “Digital Economy and Society Index" (DESI) which is updated annually and represents a composite index including several ICT related indicators that assesses Europe’s digital performance and tracks the progression of EU member states in their digital capabilities (Commission, 2017).

1.1. Open Issues and Problems

While benchmarking the EU countries may show state leaders in which areas their country fares good / poor compared to other EU states, it does give little guideline on how to improve in certain categories, neither does it state on which area to focus first.
Moreover, it is questionable how comprehensive current indices, such as DESI are, as most of them focus only on certain key areas. DESI for instance, includes only 31 indicators to measure the full digital performance of a country. Indicators related to eHealth or cybersecurity are missing. Lastly, it is unclear which measures achieve the most progress in the digital maturity of a country. While DESI stresses the importance of ICT infrastructure and ICT skills, it remains unclear how improvements in these categories affect other ones.

1.2. Thesis contribution

The insights developed through this thesis are not only relevant from an academic perspective but also from a practitioner's viewpoint.
When analyzing the impact of ICT, many studies focus on productivity gains and their implications on a nation's wealth (Ganju et al., 2015). Some other studies apply a micro perspective and investigate the effects ICT has on individuals or firms, for instance Dlodlo (2009) describes the impact of ICT education on girls and Women in South Africa or Grimes et al. (2012) show how internet connectivity positively impacts productivity. Lastly, a number of researches look into policy measures related to ICT in order to identify best practices, e.g. (Dominique et al., 2013, Haucap et al., 2016, Kongaut and Bohlin, 2015). This thesis applies a more comprehensive approach, taking into account ICT's complexity and its impact on various stakeholders. Due to the comprehensive approach, a new framework to measure the digital performance of a country is required, as existing ones do not cover the full picture. Thus, the academic contribution of this thesis is a new developed framework, which analyzes ICT's impact in much more detail than existing studies.
Practitioners, both policymakers and other governmental decision makers, gain valuable insights on how their country perform in ICT relevant areas. Further, benchmarks are provided, allowing practitioners to compare the performances of their own and all remaining EU countries. Lastly, countries are grouped to identify high and low performers and to detect common pattern of countries that tend to behave similarly.

1.3. Structure of Thesis

The thesis proceeds as follows. Chapter 2 presents the theoretical grounds of ICT and how it impacts the whole society. Having established a shared understanding on the importance of ICT, its impact and stakeholder, the chapter closes identifying some research gaps that are relevant in this context. The next chapter describes the methodology of the study, providing information on the empirical data collection and statistical methods used. Further, hypotheses that guided the development of this thesis are introduced. Chapter 4 lists the results of the empirical examinations, which reject or accept the hypotheses introduced in chapter 3, and provides further insights on the robustness of the assumptions drawn from literature. The following chapter 5 discusses the results and highlights how the research gaps can be answered thanks to the gathered empirical evidence. Moreover, it states the implications for researchers and practitioners and provides recommendations for both. The thesis closes with its limitations and future research suggestions.

2. Literature review

The objective of this chapter is to provide an overview of the topics this thesis is addressing and to establish a common understanding of the several research areas and sub-areas.
First, the scope is defined, highlighting the areas that are covered and the areas that are out-of-scope. Having set the boundaries, each area is presented in detail in the second step, delineating the state-of-the-art situation. Lastly, research gaps and uncovered areas that this thesis aims to fill are mentioned, introducing its main topic (the digital maturity of a country and how measuring its performance).
Hence, this thesis is relevant for various domains. Due to the fact that ICT represents an essential part of this study, researchers and practitioners related to information technology domain might gain a better understanding on how ICT shapes an economy. By applying a country-wise view, the findings of this thesis are especially relevant for policy-makers and researchers in the area of political science, such as political economy or regulatory economy.
As ICT will take an even bigger role in our society, it is important understanding the opportunities as well as challenges that comes with it and how to influence them. Findings of this study offer insights that can be used to influence ICT adoption and so to improve the well-being of a nation in the long term.
ICT and its influence on a nation's economy is a well-researched area. However, as the literature research will highlight, research gaps exist when not only one phenomenon shall be examined, but several combined. It represents a next step, built on previous findings in literature and confirmed through empirical data.

2.1. Relevance of ICT

Long before the arrival of the digital age, access to information and effective communication were considered important factors that spur on economic growth. Vu (2011) states that the economic growth in Japan, Hong Kong or Taiwan after 1950 can be traced back to the fact that enterprises and individuals had better access to market information. There has been a plethora of studies analyzing the link between ICT investment and economic growth, such as (Bloom et al., 2012, Brynjolfsson and Hitt, 2003, Draca et al., 2006, Gretton et al., 2004, Grimes et al., 2012, Oliner and Sichel, 2000, Pilat, 2004). The examination of this connection in depth is out of scope of this paper[2], but it will provide a glimpse of the research done on a national level that supports this theory (evidence on a firm level is provided through section 2.4).

[2] Vu (2011) provides an excellent empirical analysis on the causal link of ICT on growth

Applying a holistic view on literature regarding the contribution of ICT on economic growth shows two streams. One stream employs the growth accounting technique to judge the contribution of ICT investments to growth in percentage points and usually measured against GDP. A broad swath of studies involves EU member states, e.g. Oulton (2001) argues that investment in ICT has contributed roughly twenty percent of UK's GDP growth from 1989 to 1998. Van Ark et al. (2003) sees the relatively low investment level in ICT as main reason why European countries are lagging behind their US counterparts in productivity and GDP growth. Jorgenson (2004) found that all G7 countries[3] invested heavily in ICT at the second half of the 20th century, which led to a surge in GDP growth, especially in ICT producing industries. Lastly, Jorgenson and Vu (2007) identified ICT investments as the main driver of world GDP growth.

The second stream of studies uses cross-country regression techniques to probe the influence of ICT on economic growth. Roller and Waverman (2001) examined 21 OECD countries over a time period of 20 years and found a significant correlation between ICT investments (especially in telecommunication infrastructure) and economic growth. By analyzing annual data from 192 countries over the period 1990–2007, Gruber and Koutroumpis (2011) estimated that mobile telecommunication contributes 0.11 % to the annual GDP growth in low income countries and 0.20 % in high income countries respectively. Vu (2011) used a panel data analysis of 102 countries with data from 1996–2005, to provide empirical evidence on the positive effect ICT penetration has on economic growth.

This section offers only a snapshot of the extensive research that has been done to investigate the relationship of ICT investment and economic growth. However, the economic perspective captures only little of the big picture. Today and even more in the future, ICT takes a main part in our lives. It does influence how we interact, with who we interact and where this interaction will happen. Following sections take this fact into consideration and elaborate extensively the role ICT plays within a society.

2.2. A take on Society

Before outlining the role of ICT within a society, it is useful establishing a shared understanding of the term society. According to the Oxford dictionary, society can be described as "the aggregate of people living together in a more or less ordered community" (Press, 2018). Boundaries of a society might be related to geographical differences, such as country borders.

[3] G7 states represent the largest advanced economies and include Canada, France, Germany, Italy, Japan, the UK, and the US

In this thesis, society represents not only the people living together in one country, but also how they interact with each other. In economic terms, a society represents an economic system in which economic agents interact with each other. The economic theory adds groups of people that come together to act as one person, called legal entities. That having been said, economic agents refer to both a person or legal entity that has an active part in an economy by carrying out transactions with other economic agents. Economic agents are clustered into three institutional units, also called institutional sectors (Giovannini, 2008):

- **Households**: can be one or more individuals. Households perform three main activities: a) consume goods and services produced by other agents; b) produce goods and services that can be sold; and c) acquire real and financial assets.
- **Firms**: produce goods or offer services to generate profits which is used to acquire real and financial assets.
- **Public Administration**: acts as regulator, produces non-market services and redistributes income and wealth.

A country or economic system usually has many households in which its citizens live, a lower number (compared with household) of firms and one government, Figure 2 represents the economic system graphically.

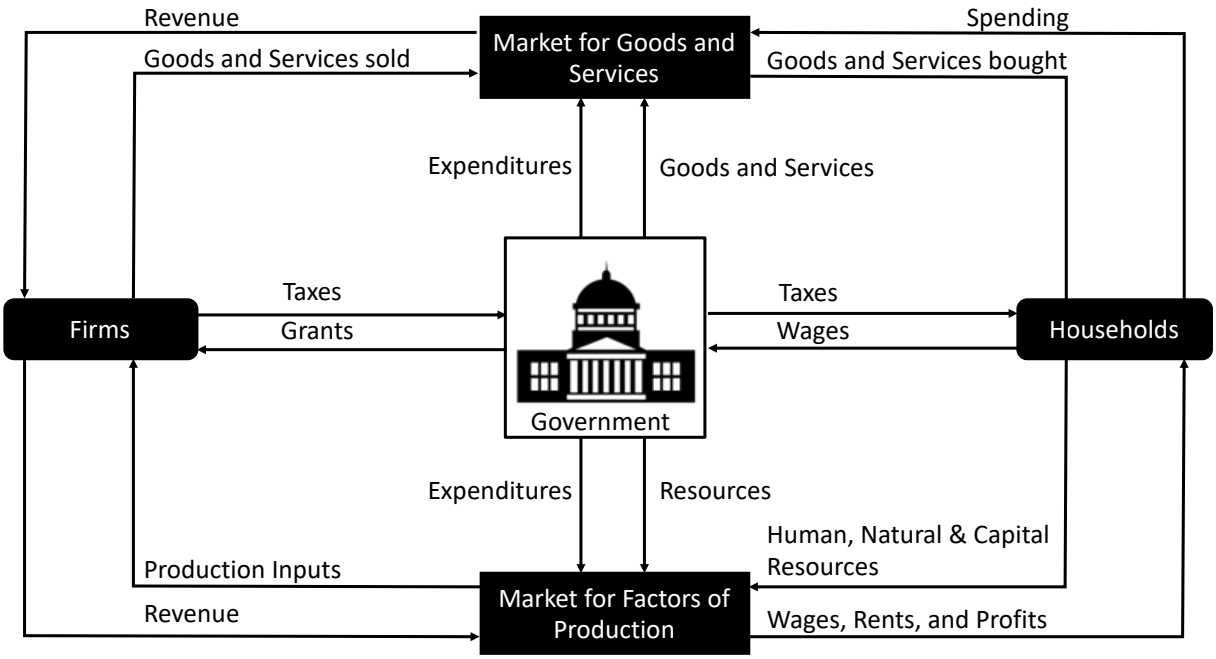


Figure 2: Economic system, based on (Giovannini, 2008)

ICT has an impact on all economic agents, but the impact varies between (and within) agents (Sein and Harindranath, 2004). Some technologies are more important for certain agents, while some other might be almost worthless for the same agents. The next paragraphs identify how ICT plays a role for each economic agent.

2.3. ICT on Citizen

ICT has a fundamental influence on citizen. It has the power to improve social capital and equal social inequality. It is able to transform education and brings it to remote societies who otherwise cannot receive those education. ICT will empower consumers, shifting buying power to consumers and improve their health through more channels to retrieve medical assistance.

Social Capital

Citizen have plenty of touchpoints with ICT in their life. One of the most essential is the internet, which is becoming almost natural in our everyday life. Contrary to earlier generations that had to change habits, children are growing up with the internet and future generation will take it for granted, as we take a TV or telephone for granted (Turow and Kavanaugh, 2003). Some may argue that the internet makes its users depressed and represents a threat to society, but Bargh and McKenna (2004) found quite opposite results. In fact, it does connect people and close ties between family and friends who live geographically separated. More social interactions will increase the social capital of a country by improving a person's self-esteem and sense of satisfaction, leading to higher well-being for citizens (Helliwell and Putnam, 2004). More evidence is provided by Ellison et al. (2007), who connects the usage of Facebook with higher social capital. Allowing graduates to keep in touch with other alumni or to enable relocated professionals to connect with former colleagues might yield strong payoffs in terms of internships, jobs and other opportunities. Bargh and McKenna (2004) also stress that the internet needs to be regulated in some way to prevent the spread of crime and terrorism (see chapter 2.5).

Social Equality

Ganju et al. (2015) provides examples in which ways ICT helps mitigating social inequality. The example used described how ICT enables women to report cases of harassment and violence (for more information see (AfDB and UNDP, 2012)). Hafkin and Huyer (2006) and Dlodlo (2009) list many more prospects on how women can increase their income, gain awareness of their rights and improve their well-being through the use of ICT. Patterson and Wilson III (2000) raised awareness on the fact that ICT might lead to social inequality if it cannot be ensured that every citizen has the same chance to get connected, irrelevant on social status or wealth. A proper way to tackle it is through education, as Nivala (2009) states "The role of education in the information society is to make sure that people have equal opportunities to achieve the competence requirements of tomorrow.". In his study, he examines the reason why Finland is scoring high in international ranking measures various aspects of social

development. He finds good reasons that Finland's "information society strategy" plays a vital role in it, empowering Finland's citizens to gain a competitive edge through the use of the internet, resulting in a better-informed society which is better prepared for a rapid changing world.

Education

Even education itself can benefit from ICT through a more diverse and effective way of teaching as well as through transfer knowledge to citizens that do not have access to such a plethora of wisdom otherwise (Ganju et al., 2015). Kozma (2005) outlines how ICT can be used to advance knowledge creation, acquisition and deepening. Cooper and Sahami (2013) illustrates how AI and online education can not only personalize education but also help to identify struggling students and provide remediation through tailored and alternative education methods. The same study shows an example of students that did not receive computer science courses in high school but were nonetheless able to study for and pass an advanced computer science exam through the use of online videos. When those online videos are complemented by an enrollment process, quizzes, assessments, assignments and other tasks of a regular course curriculum, they are called MOOCs[4]. MOOCS are on the rise and enjoy growing popularity (Colbran and Gilding, 2014, Jordan, 2014)[5]. A MOOC created by the MIT enabled a 15-year old Mongolian boy to not only to attend a course that is not provided in the entire country, but his perfect score landed him an offer from MIT (Pappano, 2013).

Consumer Empowerment

E-consumption has many perks and one of the greatest surely is the fact that consumers have full information before purchasing a good (Strauss et al., 2006). It eventually leads to cheaper goods and higher social welfare. For instance, Germany introduced the "Market Transparency Unit for Fuels", urging petrol stations to report gasoline price changes in real time. The Market Transparency Unit for Fuels passes on this information to consumer information service provider which in turn pass it on to the consumer (Bundeskartellamt, 2018). Consumer can access those information through their smartphone, pick the petrol stations with the lowest price and adjust their re-fueling habits eventually. Birger (2018) provides evidence that the introduction of the transparency unit led to the successful prevention of nontransparent pricing techniques. Pires et al. (2006) even foresee a shift of market power from suppliers to

[4] Colbran and Gilding (2014) describe MOOCs as a course that is open, participatory, distributed and supportive of life-long networked learning.
[5] More information on MOOCs and their trends can be found in the study of Jordan (2014)

consumers. However, consumer empowerment may not only result in a more informed decision-making process, but does also allow consumers to exert influence on the product design and product decision making (Füller et al., 2009). Despite all the benefits, Wathieu et al. (2002) warn that consumers may not always make decisions that make them better off when they have more control as they lack expert wisdom.

Health

ICT has the power to enhance people's health significantly. According to Deloitte (2014) having access to the internet may lower the incidence of diseases as both patients and physicians are better informed, improving health conditions this way. Moreover, the internet has the power to reform medical behaviors through new ways of interacting and monitoring with patients. The same study argues that child mortality could be reduced by seven percent through the provision of Internet access in developing countries. The Department of Health and Human Services (DHHS) of the USA believes ICT in healthcare has the potential to "improve the quality, safety, and efficiency of care while reducing disparities" as well as to enhance coordination between healthcare providers (Blumenthal, 2010). ICT will add more channels for the interaction between patient and physician. O'brien and Lazebnik (1998) found that telephone reminders increase a patient attendance to clinical appointments, may decrease level of depression (Simon et al., 2004) and improve the immunization rate (Szilagyi et al., 2002), especially in developing countries (Kaplan, 2006). Finally, ICT leads to empowerment in healthcare as well. The quantified movement describes the trend of self-tracking health related information (e.g. blood pressure, sleep habits, weight, etc.) (Swan, 2013). While this is a relatively new research area, patient-driven health care models may be central to the healthcare system of the future (Swan, 2009). Opportunities are endless, citizen will be empowered to better manage their health, independently, with peers in communities or in a consultative way with medical professionals. Once individuals have a better understanding on their health situation, they might be able to improve their health through self-experimentation and self-diagnosis of results (Swan, 2009).

2.4. ICT on Firms

ICT plays a pivot role for firms. It creates new channels to suppliers and customers that are more efficient, cheaper and more flexible. It fuels the innovation capacity of a firm and allows enterprises to boost productivity of machines and labor. Finally, it allows merchants to not only trade locally but all over the world, but also to fish for customers across regional borders.

E-Business

ICT has profound impact on firms, changing the way firm do business and disrupt entire industries. Deloitte (2014) quantifies the global impact of ICT and estimates that the resulting economic activity will bring $ 2.2trillion of additional GDP and create more than 140 million new jobs. Cordella (2006) illustrates how ICT reduces transaction costs (the costs firms occur when trading on the market) by speeding up and increasing the information density, resulting in more efficient economic exchanges and lower search, negotiation and enforcement costs. ICT can be a vehicle and enabler for a successful venture abroad (Lucchetti and Sterlacchini, 2004), or provide new channels to suppliers or customers (Kumar, 2004). Banker and Mitra (2007) as well as Bayes (2001) illustrate how farmers can exploit ICT to gain more information on prices, achieving this way higher prices for their produce and eventually being able to improve their standard of living. Many firms of developed countries state ICT helps them in improving customer relations, increasing product quality and variety and optimizing production processes (Hollenstein, 2004). Moreover, Sako (2005) argues that offshoring, enabled by ICT has benefits for both developed and developing countries. Firms in developed countries can save costs and diversify risks while firms in developing countries create new jobs, feeding more money into their economic systems. In the long-term, knowledge and technical spill-overs enable those firms to further transform and grow (Sako, 2005).

Innovation

Innovation spurs on economic growth, levels the playing field and has positive effects on GDP development (Nelson, 1993, Wong et al., 2005, Verspagen, 2005, Griffith, 2000). Almost natural is the connection between ICT and Innovation. ICT speeds up the development of new business and lowers entry barriers for entrepreneurs through new and innovative way of business creation (Wong et al., 2005). Hempell et al. (2004) investigated the link between ICT, innovation and business performances for Germany and the Netherlands. The study found that firms introducing new products, re-designing processes or adjusting their organization reap higher benefits when spending in ICT investments is high compared to firms with low ICT investments. It is further suggested that ICT innovation is more effective when conducted by own innovation efforts through spillover effects, and continuous innovating pays off more than innovating occasionally, especially for product innovations. Lastly, (Hempell et al., 2004) found a positive direct effect of product and process innovation on productivity levels.

Productivity

With the introduction of ICT, one can expect similar jumps in productivity as the industrial revolution once brought (Brynjolfsson and McAfee, 2014). Gordon (2000) argues that ICT fostered a new economy, leading to skyrocketing productivity growth in the durable manufacturing sector, especially within the manufacturing of computers and semiconductors. The study also points out that the boost in the US multi-factor productivity (MFP) growth at the end of the 1990s was primarily because of rapid technological advancements in the production of ICT goods and services. Pilat (2004) examined whether this productivity growth led to MFP growth outside the US, where ICT manufacturing is not as prevalent as in the US. The study shows that the ICT- producing sector provided significant support to the acceleration in MFP growth in Finland, Germany and France, while Gretton et al. (2004) found strong evidence for a correlation of higher ICT use and productivity growth in manufacturing and a bunch of service industry sectors. Brynjolfsson and Hitt (2003) did even discover a positive relationship between computer investment and firm productivity level: the more a firm invested in computer the more it was able to produce. Baldwin et al. (2004), Bresnahan et al. (2002) add that a high level of ICT usage is often closely associated with superior performance of the company and higher labor productivity.

E-Commerce

While the E-Business section above highlighted opportunities provided by ICT, e-commerce represents the electronic trade of goods and services. Tracking e-commerce activities over time shows that it is gaining importance for all players on the market. It used to be more relevant for small companies (Clayton et al., 2004), but recent data reverts the trend and shows that, especially for large firm s, there is no way around e-commerce (OECD, 2014). Srinivasan et al. (2002) points out e-commerce does not only customer empower, but also firms who can benchmark their e-commerce activities against competitors to identify strengths and weaknesses. The study further states, ICT provides additional tools for e-commerce to strengthen customer loyalty and gain deeper customer insights, through advanced customer relationship management systems (CRM) and other tools that allow to measure customer perceptions.

2.5. ICT on Public Administration

This chapter shows that policy makers have a lot of touchpoints with ICT and can heavily influence its adoption. Similarly to companies, the way of doing business changes and services will be more and more digitized. Having the role of a gatekeeper governments can influence

the ICT diffusion and it is their duty to establish appropriate ICT laws, regulations and incentives. Funding for ICT related projects is one of the most fruitful incentive to accelerate ICT investment in firms, while transparent regulations and a digital transformation of state services influences positively citizen's ICT adoption.

E-Government

Considering the complexity and sheer size of governments, they seem predestined to achieve improvements through the power of ICT (Gichoya, 2005). ICT can simplify interactions between citizen and public authorities thanks to the digitization of bureaucratic procedures and 24/7 access. The automation of processes will lead to less red tape and eventually saving tax payers money (OECD, 2014). Cordella (2007) argues that ICT, when implanted in the right way (following the "New Public Management" ideology), can transform bureaucracies into market-oriented organizations, which are more efficient and effective. According to the study, governments can not only improve the speed, transparency and accountability of their actions, but also reinforce the democratic values of equality and impartiality they aim representing. Offering their services through digital media achieves indirect effects as well. When governments increase their ICT adoption, citizen follow suit and become more technical inclined as they feel urged to use the new services provided. In many cases, once the online services have been tried out, citizen prefer the online over offline interaction (West, 2004). That having been said, Fabri and Contini (2001) state another area, which can significantly benefit from ICT. In their study, the researchers described extensively how ICT can revolutionize the justice system, ensuring a fairer and faster legal proceedings.

ICT Diffusion

A successful ICT diffusion depends on a number of factors: firms and citizens must be willing to adopt, and outside circumstances needs to be in favor for adoption. All those factors can be influenced through measures initiated by public authorities (Kongaut and Bohlin, 2015).
Cost is one of those important factors that hinder ICT adoption, and governments can increase competition through measures and policies (e.g. price discrimination (Haucap et al., 2016)) that eventually drive costs down. Pilat (2004) highlights that the availability of tech know-how and qualified personnel is another bottleneck for firms and impacts directly their capability to innovate. The state can counteract by nourishing an effective labor market and introduce education policies which strengthen ICT skills. Hempell et al. (2004) takes the same line and urges governments to lower both institutional and legislative barriers for labor markets. Risks associated with the usage of ICT represents another obstacle that policy makers can remove

with a transparent regulatory framework and unambiguous ICT laws. Hempell et al. (2004) goes one step further and says policies should also set incentives to innovate creating this way a competitive market for innovations.

ICT Regulation

As this thesis states throughout the whole chapter 2, ICT is a driver of social and economic growth. Not only is the ICT industry itself important as a large job and GDP growth creator (see section 2.4), but it also provides the infrastructure without modern society would not work (see section 2.6). Hence, governments and especially policy makers need to make sure to enhance ICT's contribution as much as possible through the right ICT regulation (Fransman, 2010).

ICT does not only require different laws and policies to flourish but also a tailored approach for regulation. One crucial aspect is privacy that may entail electronic health records, browsing data or social media interactions. Privacy has always been an important fact in our society but differs between cultures (Harris et al., 1995). Hence, privacy managements must fit into cultural practices and should be dynamic, especially in the networked and rapid changing world of today (Palen and Dourish, 2003). As stated above, trust in the policies and regulations will motivate citizens and firms to start adopting the use of ICT. It is a balancing act between individual freedom and government control (Newman, 2010). ICT innovation needs open access to information but it requires patents to incentivize firms to spend their money on innovation development (Corrocher et al., 2007).

ICT Funding

Lastly, governments can exert influence on ICT adoption more directly through subsidiaries or funds. Guellec and Van Pottelsberghe De La Potterie (2003) found evidence that direct financial support is more effective than indirect support, such as research performed by government or higher education institutes, when measured against company's ICT related R&D expendables. The study further notes that a continuous stream of financial supports yields more than sporadic initiatives and the right amount varies from country to country. It is especially highlighted that the right amount of funds may not be too high not too low, a subsidization rate of about 10% is suggested. ICT subsidies seem to be especially powerful when the government aims in boosting SME's innovation capabilities Atzeni and Carboni (2006). Gaggl and Wright (2017) got similar results in their study on ICT tax investments for small UK firms. Those tax cuts were keenly welcomed and used, increasing investments in ICT that resulted in a higher productivity without the reduction of workers.

2.6. ICT Infrastructure

Chapter 2.3 - 2.5 described the influence ICT has on all economic agents stated in 2.2. Taking a look at Figure 2 all economic agents interact with each other and exchange services, goods or both. What this thesis has not tackled yet, is the underlying infrastructure that enables those interactions. ICT infrastructure can be boiled down to broadband (including mobile) provision and adoption. The question this section answers is: what role does broadband play in shaping a digital society, applying a socio-technical perspective, instead of focusing on merely one dimension, such as growth. Before that, the term "broadband" is discussed to ensure a joint understanding.

Broadband defined

Broadband represents the network behind television, telephone and computers that enable those devices to communicate via voice, data and video (Sawyer et al., 2003). As these technologies tend to converge more and more, most commonly broadband is associated with any type of internet connection. A clear definition is hard to find, Council (2002) dedicates 20 pages purely on the discussion about the different definitions of broadband. In addition, the technology behind broadband changes perpetually, hence a fluid understanding of broadband is required. This becomes evident taking into account the bandwidth requirements, which vary heavily from country to country. For instance, in 2003 the broadband requirement for residential users in the UK are 560 Kbps, while South Korea starts talking about broadband when speed is over Mbps (Sawyer et al., 2003). That having been said, there is a lot of discussion about the importance of broadband speed, and some may even say nations that are not able to switch to the next-generation high speed network, that is replacing the old copper wires with fiber, will have a tremendous competitive disadvantage when competing globally (Briglauer, 2014). In its current Digital Agenda 2020, the EU states the provision of high speed broadband as one of the most important success factors to foster innovation, achieve economic growth and to improve the daily lives of citizens within the EU (Kongaut and Bohlin, 2015). Returning to the definition of broadband, and taken away the bandwidth criterion, the Broadband Stakeholder Group in the UK provides a tech neutral definition: "*Always on access, at work, at home or on the move provided by a range of fixed line, wireless and satellite technologies […] supporting genuinely new and innovative interactive content, applications and services and the delivery of enhanced public services*" (Group, 2001).

Broadband's impact on Citizens

While extensive use of broadband used to be a phenomenon observed mostly with early adopters who have particular needs and specialized knowledge (Sawyer et al., 2003), with the advent of mobile phones and inexpensive data plans, being connected to the internet is also relevant for younger generations or minorities. Mossberger et al. (2012) speaks about digital citizenships due to the fact that many offline activities (e.g. job search) became digitized. Broadband does also provide the foundation for a second observation, the growth of social connectivity (Sawyer et al., 2003). Ramifications are not clear yet and two school of thoughts have evolved. One stating that the extensive use of social media network and instant messaging resulted in social isolation (McPherson et al., 2006), while the other one argues in favor of social connectivity and found that digital citizen have more friends in both world, offline and online (Wang and Wellman, 2010). Lastly, surging broadband connectivity blurs boundaries between work and private life, as individuals are fulltime reachable in their everyday life (Haddon et al., 2001).

Broadband's impact on Firms

Section 2.4 did provide evidence on the correlation between ICT investments and growth in productivity, innovation and revenue. But how much of this growth can be attributed to broadband adoption? This subchapter sheds light on that question. Smith et al. (2002) highlight that mobile broadband offers great chances to extend and transform business, capture new markets and form new business models. Maitland et al. (2002) on the other hand doubts that additional revenues can cover the high costs of developing and deploying broadband (especially wireless) technologies. The concerns stem from the fact that it is unclear where exactly a better broadband connectivity adds value. Christensen (2001) further adds that more access coupled with higher mobility may even result in an upsurge of coordination activities among employees. However, more recent studies provide strong arguments for investing in broadband adoption. Grimes et al. (2012) confirms that broadband access is a productivity enhancing factor and estimated a productivity growth between 7-10 percent due to higher broadband adoption. Further, (Bertschek et al., 2013) noted that broadband does boost a firm's innovation capabilities and it increases the well-being of a company's workforce. In addition, broadband and mobile users of organizations require a certain type of governance, regulating security and privacy measures (Smith et al., 2002, Sawyer et al., 2003).

Broadband's impact on Public Administrations

Governments can enact broadband policies to either stimulate the supply or demand side. Not only do supply and demand factors reinforce each other, it also takes both to stimulate broadband adoption sustainably.

The supply side is often related to competition policies. According to Sawyer et al. (2003) there are two ways to promote competition, either through infrastructure competition in which market players have to build their own network, or service competition where incumbents resell part of their network capacity. Another large research focus is on setting the right incentives for investments in broadband network deployment. It is a tough trade-off for policy makers between access regulation and investment incentives, and between empowering new entrants or supporting incumbents (Grajek and Röller, 2012).

Fewer literature exists covering demand side of broadband policies. The lack of research is partly due to the fact that demand factors are not so easy to ascertain. Flamm and Chaudhuri (2007) proposed price as the leading driver of broadband demand, while Drouard (2010) investigated data of French households to determine broadband adoption and deciding factors. The authors found that education and income correlates with broadband adoption. Srinuan and Bohlin (2013) add that age, gender and region of living are relevant factors as well that needs to be considered. Regarding mobile broadband penetration, Westlund and Bohlin (2008) states low internet speed of mobile connections as central detriment, which can be rooted back to the supply side.

Research on ICT investments often lead to broadband adoption studies or include broadband in some way. Broadband can be seen as a means to connect to the internet, in a fashion that is in line with current standard. As the society becomes digital, broadband represents the medium that connects all. It has an impact on citizen, firms and public administrations, who in turn needs to promote broadband adoption and take measures to stimulate both supply and demand side.

2.7. Research Gaps

Previous chapters have emphasized the importance of ICT in our society and how complex it is to get a full picture of it. ICT has the power to empower citizens and improve their social well-being. Firms experience gains in innovation, which in turn improves productivity and creates more jobs. It is the role of governments to prepare their nations for the future and take the right actions to ensure citizens and firms have the right tools to seize the opportunities that ICT offers and be prepared for the challenges that comes with it. However, there is no "one-

size-fits-all" solution as different countries need different kind of ICT policies, regulations, etc. (Pick and Nishida, 2015). Policy makers have to consider the cultural heritage of their country (Pick and Azari, 2008), understand in which phase of the digitization path their country is (Chen et al., 2006), and identify their own ICT strengths and weaknesses in order to reduce technical weaknesses by exploiting existing strengths (Corrocher and Ordanini, 2002).

Benchmarking their country with other countries is a suitable way to find out in what areas countries perform strong and in which areas it may has improvement potential (Petrović et al., 2012). Dozens of benchmarks, scores and indexes exist but this thesis argues none of them is able to provide a comprehensive picture of the digital performance of a country. Consequently, it is hard for policy-makers to draw learnings from the results as they are incomplete. Even worse, they may misinform state leaders and urge them implementing ineffective and/or useless policies. Following, this section gives an overview on current benchmark studies, such as indexes, scores, etc. on a national level. As a general finding that holds true for all benchmark studies, they are either too specialized and measure only a very specific area of ICT or ICT related fields (e.g. e-health, freedom on the net), or they measure digital performance but do not provide a comprehensive picture capturing all ICT dimensions and how it impacts society (e.g. ICT Development index with a focus on infrastructure and ICT adoption among citizens.). Table 3 provides a list of relevant ICT benchmark studies that this thesis has considered.

Table 3: List of ICT Benchmark Studies

Nr.	Autor	Report	Index / Score	Last Year
1	World Economic Forum	The Global Information Technology Report	The Networked Readiness Index	2016
2	Huawei	Harnessing the Power of Connectivity	Global Connectivity Index	2016
3	World Bank Group	Doing Business	Doing Business Score	2017
4	The Media Institute	—	Net Vitality Index	2015
5	WIPO	Global Innovation Index Report	The Global Innovation Index	2016
6	Mastercard, Datacash, Tufts University	Digital Planet	Digital Evolution Index	2014
7	International Telecommunication Union	Measuring the Information Society Report	The ICT Development Index	2016
8	European Commission	Regional Innovation Scoreboard	Regional Innovation Index	2014
9	European Commission	Innovation Union Scoreboard	Summary Innovation Index	2015
10	European Commission	eGovernment Report	eGovernment Benchmark	2014
11	European Commission	Digital Economy & Society	Digital Economy and Society Indey	2016
12	European Commission	Digital Agenda	Digital Agenda Key Indicators	2016
13	European Commission	Benchmarking Deployment of eHealth among General Practiti	Benchmarking Deployment	2013
14	Freedom House	Freedom In The World	Freedom on the net score	2017
15	ONU	E-Government Survey	E-government rankings	2014
16	Boston Consulting Group	Which Wheels to Grease (update)	eFriction Index	2015
17	Health Consumer Powerhouse	Euro Health Consumer Index	Euro Health Consumer Index	2014
18	Bloomberg	The Bloomberg Innovation Index	The Bloomberg Innovation Index	2016
19	World Justice Project	Open Government Index	Open Government Index	2015
20	World Wide Web Foundation	Open Data Barometer	Open Data Barometer Ranking	2015
21	Open Knowledge International	Global Open Data	Global Open Data Index	2015
22	Future Brand	Thought Leadership Report	Country Brand Index	2015
23	ITU	The Global Cybersecurity Index	Global Cybersecurity Index	2016
24	UN	UN E-Government Survey 2016	E–Government Development Index	2016
25	UN	UN E-Government Survey 2016	E–Participation Index	2016
26	Istat CNEL	BES	Propensione alla brevettazione	2015
27	OECD	How's Life?	Better Life Index	2016
28	Numbeo	Quality of Life	Quality of Life Index	2017
29	Roland Berger	The Rise of the smart City	Smart City Strategy Index	2017
30	IESE Business School	IESE Cities in motion strategies	Cities in motion Index (CIMI)	2016
31	2ThinkNow	The Innovation Cities™ Program	The Innovation Cities™ Index	2017
32	World Bank Group	World Development Indicators	Several indicators	2016

It is out of scope of this work to evaluate each of these studies but it is worth to delve into one of them exemplary: DESI.

The Digital Economy and Society Index (DESI) comes closest to what this thesis is aiming for, measuring the digital performance of the EU member states. It is composed of five dimensions, respecting this way the complexity ICT has and the wide span of stakeholder it impacts. The five dimensions mentioned are: Connectivity, Digital Skills, Use of Internet, Integration of Digital Technology and Digital Public Services (Commission, 2017). While the five dimensions consider all stakeholders identified in chapter 2.2, it does not cover the whole spectrum on how ICT impacts society, described through chapters 2.3 - 2.6. The first dimension "Connectivity" compares ICT infrastructure in terms of broadband coverage, speed and affordability, but does not reveal any information on broadband competition which may yield insightful information on why broadband coverage or affordability is low. The subsequent two domains "Digital Skills" and "Use of Internet" emphasizes the importance of digital citizenships and measure the technical proliferation and internet usage of citizens. However, it does not yield any insights on e-health, which highlights the empowerment of citizens through ICT best. The fourth domain "Integration of Digital Technology" sheds light on the ICT adoption of firms, but mainly related to internet. It provides little information on innovation which fuels labor and machine productivity. Finally, the last domain "Digital Public Services" offers information on how digital a government acts, or in other words how many of their services are already digitized and used from its citizen. It remains shy on delivering insights regarding ICT privacy and security measures, ICT subsidies, and other ICT related policies.

As pointed out in this thesis, ICT impacts a society heavily, but no benchmark is able to provide a comprehensive picture on how countries fare against each other. The OECD (2014) puts its finger on the problem and states "New statistical tools are needed to measure the digital economy". In particular, the authors argue that existing statistic measures are able to estimate ICT diffusion, but lack of the capability to keep up with the new and rapidly evolving technologies as well as how firms and citizen deploy them. Furthermore, the study provides a guideline on the aspects new measurement frameworks should consider, which can be summarized with the following six points:

- Enhance ICT investment linked with macroeconomic performance measurability;
- Account for new skills needed in a digital economy;
- Include security, privacy and consumer protection;
- Measure ICT's impact on social goals and society;
- Capitalize comprehensive, high quality data infrastructure; and

- Develop a statistical quality framework able to exploit the internet as data source.

This thesis and the framework it suggests represents an answer to that call for action and aims to fill the above explained research gap.

As a consequence of this gap, policy makers have few signposts to guide the design and implementation of effective ICT policies. To answer the question "how to improve?", literature suggests alternative methods instead of the commonly used ranking models based on Composite Indices (CIs). Several researchers propose "multi-level outranking" which benchmarks countries, allowing to track relevant practice examples and enabling policy makers to apply those learnings within their own country (Petrović et al., 2012, Dominique et al., 2013). The main contribution this method offers is the development of a so called "optimal development path", filtering this way inadequate policy measures. In other words, the optimal path consists of balanced and stepwise improvement steps orientating on countries with similar characteristics and slightly better performance, providing an easier to grasp guidance for government leaders in their policy making (Petrović et al., 2014). Even though those studies provide support for decision making, they lack even more of comprehensiveness and include only few indicators. It remains unclear whether predictions of these model improve with additional indicators as the calculation may lead to more than one "optimal development path" or many that are close together. However, comparing countries that act similar reveals insightful information that policy makers can use in their decision making, e.g. to prioritize ICT policies. Developing this thought further, in a second step, the new generated composite index DMI is used to analyze all European member states on similar behavior, extracting this way insights on "how to improve" without sacrificing comprehensiveness, and so fill the second identified research gap.

3. Methodology

The methodology part builds on the identified gaps in the literature research and states the research questions which this thesis aims to answer. Next, it provides a comprehensive and accurate description of the methods used as well as how data was gathered and analyzed, ensuring verifiability and transparency of this paper.

3.1. Research Objectives

The literature review highlighted the importance on ICT for a nation's growth. While there are few who would disagree about the importance, it is unclear how to measure the digital performance of a country entirely. Some indexes and scores exist, but they do not provide a comprehensive picture as pointed out in chapter 2.7. Hence, the first research question is:

RQ1: How can the digital maturity of a country be measured in order to provide policy makers with profound, comprehensive insights for increasing it?

Using the findings of the literature review as guiding principles, a new composite index is created. This requires the creation of a new framework and hypotheses. The framed hypotheses need to be confirmed in a further step, giving the index credibility and robustness. Validity is provided through empirical data collection and analysis.

Once the index is established, it is used to gain a more profound knowledge of the digital maturity of a country and to determine measures for policy makers to improve. Thus, the second research question is:

RQ2: What are features of a digital high / low performer? Countries that improved / worsen their digital performance, which were the relevant factors for the advancement / decline? Are there common patterns so that several countries pursue a similar digital development?

Gaining insights through benchmarking countries can be a powerful tool for governments in designing policies and prioritizing measures. In order to extract valuable information, countries countries are grouped based on their performance for two different time periods. This allows to show countries that fare good or bad and to analyze the factors that led to the country's respective position.

In a subsequent step, the results of the two time periods are compared and changes between groups are investigated. For countries that improved, it may highlight specific characteristics of countries that manage ICT more successfully than other countries. Understanding in which areas improvements stem from allow policy makers to learn about best practices and how to apply them. On the other side, by looking into countries that did not improve, ineffective

measures can be revealed enable policy makers to prioritize ICT measures and to set a focus on more effective initiatives.

Finally, common patterns in the digital journey for several countries can provide further insights as they may highlight relevant outside factors (such as similar geographies or shared cultural heritages) and demonstrate if countries exist that behave homogenously.

3.2. Literature Analysis

The literature analysis aims to create a current view of the impacts ICT has on society, considering a broad swath of studies that conduct research on ICT and how it shapes a country. Through the analysis of academic papers, scientific books and whitepapers, it has been possible to describe the impact of ICT thoroughly, including not only one but all involved stakeholder, such as citizens, firms and public administrations. The research of the literature has been conducted on Scopus and Google Scholar, selecting material mainly from Journals of Engineering, Social Science, Business, Information Technologies and Political Science.

The findings of the literature analysis were key to develop the research objects in section 3.1 and the research framework in section 3.3.

The literature research was conducted in several steps. Due to the fact that ICT is such a large topic, it was important to decide which research areas got included and what was out of scope. For this thesis, it was relevant to firstly define what society actually means, who belongs to a society and then secondly, identify how societal members are effected from ICT. For this second step, a number of key words were used to identify relevant papers describing ICT's impact on the whole society. The level of relevance was decided through various factors, such as how often the paper got cited, the importance of the journal and whether the papers provided answers related to the researched keyword. Often, within the identified papers further sources were quoted which provided additional viewpoints on a topic or more evidence for a specific statement. As relevant areas became more concrete, experts of specific research areas emerged (such as Nicoletta Corrocher for ICT innovation or Erik Brynjolfsson regarding the impact on firms). Consequently, other published studies of those experts were searched and added, if they provided further insights about those research areas.

Finally, in a third step, research papers, whitepapers or similar released by the European Commission, the OECD[6], and private companies (e.g. Deloitte) were considered, enriching the thesis with "real-world" evidence and practical insights.

[6] The OECD provides a forum for discussing issues and reaching agreements on a federal level

A total of 146 academic references were found and checked of which 130 were cited in the thesis. Endnote was used as citation managers, using “Harvard – Anglia” as citation style.

3.3. Research Framework

A composite index needs to respect several aspects to gain acceptance from all stakeholder involved. As the term "composite" suggests, a composite index is made up of several (interdependent) parts, adding up to one index. Hence, it represents an interplay of technical experts in selecting the right indicators, mathematicians and statisticians in ensuring significance and data reliability as well as economists who often use such indexes in their policy making. Therefore, it is crucial that the development of a composite index follows best practices in terms of methodology and data selection, is transparent allowing outsiders to completely understand its composition and is well documented to justify the numerical results. The construction of the Digital Maturity Index is based on the recommendation of the "Handbook on Constructing Composite Index", released 2008 by the "Organization For Economic Co-Operation And Development" (OECD) and the "Econometrics and Applied Statistics Unit" of the "Joint Research Centre" (JRC) of the European Commission in Ispra, Italy (OECD, 2008). Having said that, the process has been adjusted when necessary, e.g. by either changing the sequence, combining two sequential steps into one step or eliminating redundant steps. Figure 3 illustrates the adjusted process.

Figure 3: Process of Constructing a Composite Index based on (OECD, 2008)

3.3.1. Theoretical framework

The first step sets the foundation for the whole index by developing a guideline to follow for the selection of single indicators and introduces categories and sub-categories in which the indicators can be clustered. It involves the support of all stakeholders that aim to use the index; especially technical expertise is needed to ensure the selection of relevant input variables. Expert knowledge could be retrieved from scientific sources and the Digital Innovation Observatories of the School of Management of Politecnico di Milano, in particular from the Digital Agenda Observatory. As a result of this phase, a clear understanding and definition of the phenomenon to be measured is established, entailing the overall structure with its categories and sub-categories (if needed).

Building on the concept delineated in the literature section, four main dimensions have been identified that are effected by ICT: Economic agents (Citizen, Firms and Public Administration) and Infrastructure which represents the bedrock of Information and Communication Technology. Another main point of differentiation to other indexes lies in the next level of the index. Each category has two sub-categories distinguishing enabling factors from achieved results. This will allow to further understand correlations between supplying certain technologies and the adoption of these. It may discover that not every enabling factor can be turned into an achieved result, thus, stressing more successful measures and reveal areas of digitization yielding only little, if any, improvements. Figure 4 shows the theoretical framework in a graphical illustration.

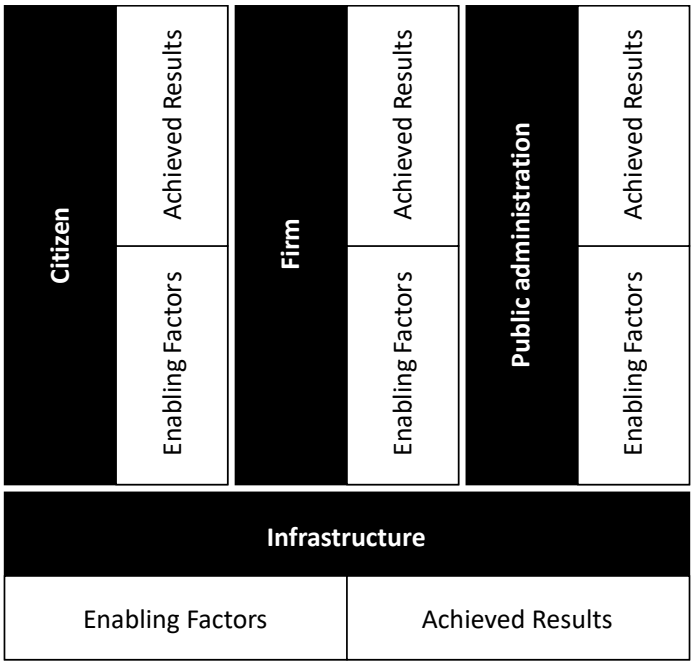


Figure 4: Graphical illustration of the theoretical Framework DMI

3.3.2. Hypotheses

As stated before, the design of the framework is based on literature evidence and expert knowledge. Following are the hypotheses stated which drove the methodological framework design.

H1: Progress in Citizen Enabling Factors does influence positively the Achieved Results within the Citizen domain

Enabling factors for citizens include all measures, programs and initiatives that equip citizens with the right tools, skills and methods to access and use ICT. An evident example is the number of "Individuals who have obtained ICT skills through formal educational institutions", highlighting the minimum number of individuals who are able to use a computer and access

the internet. Another reasonable indicator is the number of households with a computer, emphasizing the obvious fact that citizens do not only need to be educated on how to use ICT systems, but also need to get their hands on the respective hardware.

Hypothesis 1 assumes that those enabling factors will positively influence the achieved results within the citizen domain. Building on the indicator mentioned as enabling factors, it is expected once citizens know how to use a PC and have access to one, they would actually use it, e.g. to access the internet. As Choudrie and Lee (2004) pointed out, citizen prepared to use ICT will eventually drive up the demand for it. It is further expected that, over time, citizens will change their digital behavior and ICT will play a bigger role in their daily life as ICT usage represents the common way to acquire knowledge (Nivala, 2009). Consequently, former offline activities will be carried out online, such as social interactions, online banking, shopping or education (Bargh and McKenna, 2004, Colbran and Gilding, 2014, Cooper and Sahami, 2013, Wathieu et al., 2002). Table 4 offers an overview of all indicators within the Citizen category, including both enabling factors and achieved results[7]. However, which of those indicators presented ended up being used depends on the data availability of the indicator (see chapter 3.6).

Table 4: Indicators of the Citizen domain

Indicator	Sub-category
Households with access to the Internet at home	Enablers
Individuals who have obtained ICT skills through formal educational institutions	Enablers
Households with computer	Enablers
Secure Internet servers	Enablers
Individuals who have used internet in the last 3 months	Achieved results
Individuals who have used internet in the last 12 months	Achieved results
Individuals who are regular internet users (at least once a week)	Achieved results
Individuals who are frequent internet users (every day or almost every day)	Achieved results
Individuals using a laptop/tablet to access the internet, away from home or work	Achieved results
Individuals who have never used the internet	Achieved results
Diversification index for the activities realized online by internet users	Achieved results
Reading / downloading online newspapers / news magazines	Achieved results
Playing or downloading games, images, films or music	Achieved results
Households subscribed to Video on Demand	Achieved results
Individuals watching video on demand from commercial services	Achieved results
Looking for information about goods and services online	Achieved results
Using online banking	Achieved results
Telephoning or video calls (via webcam) over the internet	Achieved results
Uploading self-created content to be shared	Achieved results
Participating in social networks, over the internet, last 3 months	Achieved results
Looking online for a job or sending a job application	Achieved results
Doing an online course (in any subject)	Achieved results

[7] More information about all indicators can be obtained through Annex I: Full KPI list, adding the definition and unit of measure

Looking online for information about education, training or course offers	Achieved results
Taking part in on-line consultations or voting to define civic or political issues	Achieved results
Used internet storage space to save documents, pictures, music, video or other files	Achieved results
Individuals who have written a computer program using a specialised programming language	Achieved results
Digital Skills Indicator (internet users)	Achieved results
Digital Skills Indicator (all individuals)	Achieved results
Individuals with basic or above basic digital skills	Achieved results
Digital Skills - Information domain	Achieved results
Basic or above basic Digital Skills - Information domain	Achieved results
Digital Skills - Communication domain	Achieved results
Basic or above basic Digital Skills - Communication domain	Achieved results
Digital Skills - Problem solving domain	Achieved results
Basic or above basic Digital Skills - Problem solving domain	Achieved results
Digital Skills - Software for content manipulation	Achieved results
Basic or above basic Digital Skills - Software for content manipulation	Achieved results
Digital skills indicator (internet users) - pilot 2012/2014	Achieved results
Individuals with basic or above basic digital skills - pilot 2012/2014	Achieved results
ICT Access - Computer Ownership	Achieved results
Seeking online information about health	Achieved results
Individuals experienced financial loss	Achieved results
Individuals experienced abuse of personal information and/or other privacy violations	Achieved results
Individuals caught a virus or other computer infection resulting in loss of information or time	Achieved results
Individuals who know that cookies can be used to trace movements of people on the internet	Achieved results
Individuals using anti-tracking software	Achieved results
Individuals not allowing use of personal information for advertising	Achieved results

H2: Progress in Firm Enabling Factors does influence positively the Achieved Results within the Firm domain

Firms represent the second main player of an economy which justifies a separate category in the DMI. As explained in the literature review, ICT can have a huge impact on a nation's wealth by creating new jobs for example. These jobs will be offered by firms, playing this way a crucial role in the growth of a nation's economy (Deloitte, 2014). Enablers can be investments in ICT infrastructure or R&D projects, the employment of ICT specialists or smart working initiatives (Hempell et al., 2004, Bertschek and Fryges, 2002, Bresnahan et al., 2002). Once few or more enabling measures are installed and continuously enhanced, a positive influence on the achieved results of the Firm category is expected in Hypothesis 2. Due to the fact that a firm can improve on several dimensions, scores of indicators measuring achieved results of a firm exist. Some indicators measure how much an organization uses ICT applications within their organization, resulting in process automation which in turn increases labor effectivity (Pilat, 2004). A range of indicators are related to the online provision of information, goods,

services, providing this way more channels for customer interaction and a better customer service that will yield in higher customer loyalty and more turnover (Pilat, 2004, Hollenstein, 2004). Furthermore, Bresnahan et al. (2002) found out that higher ICT adoption increases productivity. A high usage of ICT can be determined through the digital intensity score which counts how many out of 12 relevant technologies are used by each firm. Table 5 lists all indicators of the Firm category.

Table 5: Indicators of the Firm domain

Indicator	Sub-category
Total investment in networks by the electronic communications sector	Enablers
Enterprises providing portable devices to some of their persons employed	Enablers
Enterprises using any computer network for sales (at least 1%)	Enablers
Enterprises providing persons employed a remote access to the enterprise's e-mail system, documents or applications	Enablers
Enterprises providing portable devices to more than 20% of their employed persons	Enablers
Persons employed which were provided a portable device by their employer (business sector)	Enablers
Enterprises using mobile Internet to run business applications	Enablers
Enterprises paying to advertise on the internet	Enablers
Enterprises analyzing big data from any data source	Enablers
Persons employed using computers with access to the Web at work (business sector)	Enablers
Science and technology graduates	Enablers
Enterprises employing ICT specialists	Enablers
Enterprises reporting hard-to-fill vacancies for jobs requiring ICT specialist skills	Enablers
Persons Employed with ICT Specialist Skills (broad measure)	Enablers
Enterprises where ICT functions are mainly performed by external suppliers	Enablers
Enterprise provided training to their personnel to develop/upgrade their ICT skills	Enablers
Enterprises tracking internet users for targeted advertising	Enablers
Enterprises with a formally defined ICT security policy	Enablers
Import of ICT goods and services	Enablers
Employment of the ICT sector	Enablers
Business R&D expenditure of the ICT sector	Enablers
Total revenues of the electronic communications sector	Achieved results
Fixed voice termination rate	Achieved results
Local Loop Unbundling: total monthly charge	Achieved results
Individuals ordering goods or services online	Achieved results
Individuals ordering goods or services online, from sellers from other EU countries	Achieved results
Individuals ordering physical goods online	Achieved results
Individuals ordering services online	Achieved results
Individuals ordering content or software that were delivered or upgraded online	Achieved results
Individuals ordering content or software delivered online or offline	Achieved results
Individuals selling goods or services online (e.g. via auctions)	Achieved results
Individuals who did not encounter problems when buying/ordering goods or services over the internet for private use	Achieved results
Total electronic sales by enterprises, as a % of their total turnover	Achieved results
Enterprises having done electronic sales to other EU countries in the last calendar year	Achieved results
Enterprises exploiting the "Business to Consumers" opportunities of web sales	Achieved results
Enterprises that share internally electronic information with an ERP	Achieved results
Enterprises using Customer Relationship Management (CRM) software	Achieved results

Enterprises sharing electronic information on the supply chain	Achieved results
Enterprises sending e-invoices (derived indicator)	Achieved results
Enterprises having a web site or homepage	Achieved results
Enterprises having a website with some sophisticated functionalities	Achieved results
Enterprises with High levels of Digital Intensity	Achieved results
Enterprises with Very Low level of Digital Intensity	Achieved results
Digital Intensity score for Enterprises	Achieved results
Enterprises using Radio Frequency Identification (RFID) technologies	Achieved results
Enterprises using RFID technologies for person identification or access control	Achieved results
Enterprises using RFID for product identification	Achieved results
Enterprises using social media	Achieved results
Use two or more social media	Achieved results
Buy Cloud Computing services used over the internet	Achieved results
Buy Cloud Computing services of medium-high sophistication	Achieved results
workers who judge their current ICT skills insufficient for changing job within a year	Achieved results
Security concerns kept individual from ordering or buying online	Achieved results
Enterprises advertising online based on the geolocation of internet users	Achieved results
Export of ICT goods and services	Achieved results
Value added of the ICT sector	Achieved results
Labor productivity of the ICT sector (per person)	Achieved results
Enterprises using any computer network for purchases (at least 1%)	Achieved results

H3: Progress in Public Administration Enabling Factors does influence positively the Achieved Results within the Public Administration domain

Governments have a crucial role in the digital progress of a country and their measures and policies may influence firms, individuals, or both. Besides putting in place ICT empowering and innovation friendly policies, governments itself need to be a role model, lead by example and offer its services digitally (West, 2004). Thus, Public Administration enablers are not only related to the policies and laws related to ICT, but also include indicators measuring services a government provides online.

A correlation between enabling factor and achieved results can be illustrated through the following example. The enabling factors of the Public administration category include several indicators highlighting services a government offers digitally, for instance the KPI "Online Service Completion" measures how many steps of a so called public service life event (e.g. enrolment into higher education, job search or declaring income taxes[8]) can be performed online. Some other indicators relate to public ICT R&D spending or to the total cost of ICT projects or laws related to ICT. Hypothesis 3 assumes that those indicators influence the Public Administration achieved results. By offering more governmental services online, citizens will accept those services and start using them (Chen et al., 2006). If the experience was positive,

[8] Capgemini (2012) provides more information about the eGovernment indicators

citizens will not only most likely use those services again, but also encourage friends to use them too (Carter and Bélanger, 2005). Moreover, West (2004) argues that public authorities need to publicize the existence of governmental service portals, hence a successful ICT promoting strategy is key in order to foster e-government adoption.

All these measures mentioned lead to an improvement of the eParticipation score, an index categorized as achieved result and created by the United nations aiming to accelerate the provision of information by governments to citizens through digital means (Nations, 2018). Revised ICT laws will smooth the red tape for interactions with the government, allowing to speed up typically very long processes (Ke and Wei, 2004). This impact can be measured through two other achieved result indicators, the government effectiveness indicator or in improvements of data communication between healthcare providers, general practitioners and pharmacists. Table 6 lists all indicators of the Public Administration category.

Table 6: Indicators of the Public Administration domain

Indicator	Sub-category
Online Service Completion	Enablers
Pre-filled forms	Enablers
Laws relating to ICTs	Enablers
Government success in ICT promotion	Enablers
Importance of ICTs to government vision of the future	Enablers
Computers for educational purposes	Enablers
Schools having a website	Enablers
Internet access in schools	Enablers
GBAORD - Government budget appropriations or outlays for research and development	Enablers
Public ICT R&D spending (GBAORD in the field of ICT)	Enablers
Total EC funding to participants in H2020 ICT projects	Enablers
Total cost of H2020 ICT projects	Enablers
H2020 effective co-financing rate	Enablers
Number of distinct organizations participating in H2020 ICT projects	Enablers
Number of distinct organizations participating in H2020 ICT projects for the first time	Enablers
EC funding to participants in FP7-ICT projects	Enablers
Total cost of FP7-ICT projects	Enablers
FP7 EC effective co-financing rate	Enablers
Total number of participations in FP7-ICT projects	Enablers
Average EC funding per participation in FP7-ICT projects	Enablers
Number of distinct organizations participating in FP7-ICT projects for the first time	Enablers
Number of distinct organizations participating in FP7-ICT projects	Enablers
Open Data Barometer	Enablers
Individuals interacting online with public authorities, last 12 months	Achieved results
Individuals submitting completed forms to public authorities, over the internet, last 12 months	Achieved results
Individuals interacting online with public authorities, last 12 months	Achieved results
E Participation Index	Achieved results
Government effectiveness	Achieved results
ICT use and government efficiency	Achieved results
Impact of ICTs on access to basic services	Achieved results

Making an appointment with a practitioner via a website	Achieved results
GPs using electronic networks to transfer prescriptions to pharmacists	Achieved results
GPs exchanging medical patient data with other healthcare providers and professionals	Achieved results
On-line booking of appointments	Achieved results
ePrescriptions	Achieved results
Global Security Index	Achieved results
Total number of participations in H2020 ICT projects	Achieved results
Average EC funding per participation in H2020 ICT projects	Achieved results
Open Data	Achieved results

H4: Progress in Infrastructure Enabling Factors does influence positively the Achieved Results within the Infrastructure domain

The ICT infrastructure (fixed and mobile broadband) represents the backbone of a digital society as it makes it possible for citizen, firms and public administrations to access the internet (Sawyer et al., 2003). Hence, infrastructure is often seen as the most important layer for a digital society, Choudrie and Lee (2004) sees broadband similarly important as roads, rail, electricity or other national infrastructure . The correlation between enabling factors and achieved results seems to be quite natural. Once access to fixed-broadband or mobile coverage is provided and the price for these services is affordable it is assumed in Hypothesis 4 that subscriptions and take-up of those services rises (Drouard, 2010). Table 7 gives an overview about all indicators of the infrastructure category.

Table 7: Indicators of the Infrastructure domain

Indicator	Sub-category
Standard fixed broadband coverage/availability (as a % of households)	Enablers
Rural standard fixed broadband coverage (as a % of households)	Enablers
NGA broadband coverage/availability (as a % of households)	Enablers
New entrants' share in fixed broadband subscriptions	Enablers
Actual download speed of fixed broadband subscriptions	Enablers
Monthly price of standalone internet access	Enablers
1d1 Fixed BB-Price	Enablers
Monthly price of Fixed Broadband Internet Access offers including Fixed Telephony	Enablers
Monthly price of Internet Access + Fixed Telephony + TV bundles	Enablers
Affordability of standalone Fixed Internet Access (minimum price offer)	Enablers
Advanced 3G mobile broadband (HSPA) coverage (as a % of households)	Enablers
4G mobile broadband (LTE) coverage (as a % of households)	Enablers
1b2 4G Coverage	Enablers
Mobile roaming price per minute	Enablers
Spectrum assigned for wireless broadband in EU harmonized bands	Enablers
Mobile voice termination rate	Enablers
IPv6 readiness - websites having a AAAA coverage in DNS records (as % of most visited websites)	Enablers
Fixed broadband subscriptions	Achieved results
Fixed broadband take-up (subscriptions/100 people)	Achieved results
DSL subscriptions share in fixed broadband	Achieved results

Households having a broadband connection	Achieved results
Households with fixed broadband connection	Achieved results
Enterprises having a fixed broadband connection	Achieved results
Enterprises having a fast-fixed broadband connection	Achieved results
Share of fixed broadband subscriptions >= 2 Mbps - Advertised download speed	Achieved results
Share of fixed broadband subscriptions >= 10 Mbps - Advertised download speed	Achieved results
Share of fixed broadband subscriptions >= 30 Mbps - Advertised download speed	Achieved results
Share of fixed broadband subscriptions >= 100 Mbps - Advertised download speed	Achieved results
Households that have no access to Internet at home, because the costs are too high	Achieved results
Total number of subscriptions (SIM cards)	Achieved results
Take-up of mobile - active SIM cards for voice or data	Achieved results
Take-up of mobile broadband (subscriptions/100 people)	Achieved results
Market share of leading operator (in % of active SIM cards)	Achieved results
Individuals accessing the Internet through a mobile phone via UMTS (3G)	Achieved results
Average Revenue per User (ARPU) in the Retail Mobile Market	Achieved results

H5: Progress in Public Administration Enabling Factors does influence positively the Achieved Results within the Citizen domain

As more and more governmental services are provided online, citizens become more technical inclined, thus, their acceptance of using ICT in other areas increases (Drouard, 2010). Furthermore, as Kongaut and Bohlin (2015) highlight, public authorities can (and should) influence the demand side of internet adoption through education. Fostering ICT education in schools will lead to higher IT literacy and consequently, higher internet usage. Lastly, Carter and Bélanger (2005) point out that trustworthiness increases citizen's intention to use the internet. The establishment of relevant ICT laws that addresses citizen's fear of security or privacy loss is another key determinant to boost citizen's internet adoption.
Hypothesis 5 states that an advancement of the Public Administration enablers has positive effects of Citizen's achieved results.

H6: Progress in Public Administration Achieved Results does influence positively the Achieved Results within the Firm domain

Public Administration can increase firm's ICT usage through direct or indirect measures. According to Guellec and Van Pottelsberghe De La Potterie (2003), direct funding related to ICT programs stimulate business-funded R&D. Firms will use the funds to introducing new products, re-designing processes or digitize their organization in order to increase sales or productivity (Hempell et al., 2004, Gretton et al., 2004). In addition, regulations that ensure access to open data fosters a firm's ability to innovate, spurring on ICT investments and increasing this way the digital intensity of firms (Corrocher et al., 2007).

Thus, hypothesis 6 claims that Progress in Public Administration Achieved Results does influence positively the Achieved Results within the Firm domain.

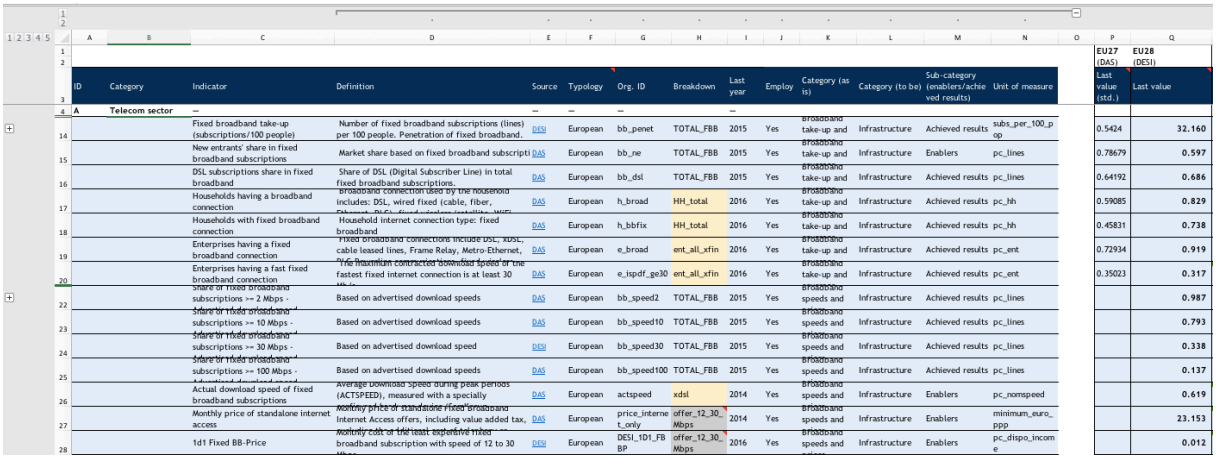
3.4. Data Selection

Having set up the basic framework, in the consequent steps indicators are selected based on specific criteria such as the analytical reliability, measurability, data coverage (e.g. years, country, etc.), dependencies, and importance of the indicators to the phenomenon being measured. The objective of this step is to examine the quality of the indicators, discuss their appropriateness by revealing strengths and weaknesses, and finally to create a list of all indicators, specifying their data characteristics (e.g. availability, source, unit, etc.).

3.4.1. Main Data

DESI retrieves all its indicators from the Digital Agenda Scoreboard (DAS), a set of indicators selected by the European Commission and divided into thematic groups, which illustrate some key dimensions of the European information society (for instance the level of Broadband coverage). It includes more than 100 freely accessible indicators and represents the starting point of the Digital Maturity Index[9]. After downloading the dataset, the data had to be prepared in a more user-friendly format, enriched with further information such as the new category and sub category. Several technical impediments had to be considered, inter alia: (i) selecting the right breakdown of each indicator. A breakdown can be seen as an additional level of detail for an indicator. For instance, an indicator related to business, can be broken into the specific type of business (e.g. manufacturing, transportation, etc.) or including all businesses; (ii) unit of measure. Some indicators have more than one possible unit of measure. In order to keep consistency and comparability, equal units must be chosen. A common example here is the option of displaying absolute or percentage values; and (iii) time period. For the DMI it was decided to use yearly values. However, the dataset included quarterly and monthly values in addition. In a final step, the mapping was accomplished in a spreadsheet, listing the indicators in rows and matching them with the respective country and year in the columns (see Figure 5).

[9] The dataset can be downloaded at: http://semantic.digital-agenda-data.eu/dataset/digital-agenda-scoreboard-key-indicators



ID	Category	Indicator	Definition	Source	Typology	Org. ID	Breakdown	Last year	Employ	Category (as is)	Category (to be)	Sub-category (enablers/achieved results)	Unit of measure	EU27 (DAS) Last value (std.)	EU28 (DESI) Last value
A	Telecom sector	–	–	–	–	–		–							
		Fixed broadband take-up (subscriptions/100 people)	Number of fixed broadband subscriptions (lines) per 100 people. Penetration of fixed broadband.	DESI	European	bb_penet	TOTAL_FBB	2015	Yes	Broadband take-up and	Infrastructure	Achieved results	subs_per_100_pop	0.5424	32.160
		New entrants' share in fixed broadband subscriptions	Market share based on fixed broadband subscripti	DAS	European	bb_ne	TOTAL_FBB	2015	Yes	Broadband take-up and	Infrastructure	Enablers	pc_lines	0.78679	0.597
		DSL subscriptions share in fixed broadband	Share of DSL (Digital Subscriber Line) in total fixed broadband subscriptions.	DAS	European	bb_dsl	TOTAL_FBB	2015	Yes	Broadband take-up and	Infrastructure	Achieved results	pc_lines	0.64192	0.686
		Households having a broadband connection	Broadband connection used by the household includes: DSL, wired fixed (cable, fiber,	DAS	European	h_broad	HH_total	2016	Yes	Broadband take-up and	Infrastructure	Achieved results	pc_hh	0.59085	0.829
		Households with fixed broadband connection	Household internet connection type: fixed broadband	DAS	European	h_bbfix	HH_total	2016	Yes	Broadband take-up and	Infrastructure	Achieved results	pc_hh	0.45831	0.738
		Enterprises having a fixed broadband connection	Fixed broadband connections include DSL, xDSL, cable leased lines, Frame Relay, Metro-Ethernet,	DAS	European	e_broad	ent_all_xfin	2016	Yes	Broadband take-up and	Infrastructure	Achieved results	pc_ent	0.72934	0.919
		Enterprises having a fast fixed broadband connection	The maximum contracted download speed of the fastest fixed internet connection is at least 30	DAS	European	e_ispdf_ge30	ent_all_xfin	2016	Yes	Broadband take-up and	Infrastructure	Achieved results	pc_ent	0.35023	0.317
		Share of fixed broadband subscriptions >= 2 Mbps -	Based on advertised download speeds	DAS	European	bb_speed2	TOTAL_FBB	2015	Yes	Broadband speeds and	Infrastructure	Achieved results	pc_lines		0.987
		Share of fixed broadband subscriptions >= 10 Mbps -	Based on advertised download speeds	DAS	European	bb_speed10	TOTAL_FBB	2015	Yes	Broadband speeds and	Infrastructure	Achieved results	pc_lines		0.793
		Share of fixed broadband subscriptions >= 30 Mbps -	Based on advertised download speed	DESI	European	bb_speed30	TOTAL_FBB	2015	Yes	Broadband speeds and	Infrastructure	Achieved results	pc_lines		0.338
		Share of fixed broadband subscriptions >= 100 Mbps -	Based on advertised download speeds	DAS	European	bb_speed100	TOTAL_FBB	2015	Yes	Broadband speeds and	Infrastructure	Achieved results	pc_lines		0.137
		Actual download speed of fixed broadband subscriptions	Average download speed during peak periods (ACTSPEED), measured with a specially	DAS	European	actspeed	xdsl	2014	Yes	Broadband speeds and	Infrastructure	Enablers	pc_nomspeed		0.619
		Monthly price of standalone internet access	Monthly price of standalone fixed broadband Internet Access offers, including value added tax,	DAS	European	price_internet_only	offer_12_30_Mbps	2014	Yes	Broadband speeds and	Infrastructure	Enablers	minimum_euro_ppp		23.153
		1d1 Fixed BB-Price	Monthly cost of the least expensive fixed broadband subscription with speed of 12 to 30	DESI	European	DESI_1D1_FBBP	offer_12_30_Mbps	2016	Yes	Broadband speeds and	Infrastructure	Enablers	pc_dispo_income		0.012

Figure 5: Reworked dataset, including DAS and DESI indicators

3.4.2. Additional Data

In a subsequent step, the index was enriched with further indicators stemming from other indexes. Therefore, an initial scouting for other indexes related to ICT has been carried out and single indicators that met the following requirements has been added:

I. The indicator must measure technical advancement which is not covered by either DAS or DESI,
II. It must include all (or nearly all) European countries,
III. It must provide yearly data and cover at least three years, ideally consecutively and only after 2010, and
IV. Data must be open accessible.

Annex II: Overview of Indexes provides an overview on all indexes that has been examined, and Annex III: Additional Indicators shows in detail the indicators added and excluded, including the explanation for the respective decision.

3.5. Handling of missing data

The quality of the final index heavily depends on the data quality; hence a complete data set is needed. In this third step missing values will be identified which eventually signal the reliability of the data and eventually, the composite index itself.

In this third step, which can be also described as data cleaning, it is crucial to assure each indicator meets a certain threshold for the respective analysis conducted. As a general starting point, zeros and empty values have been examined to ensure the correctness of empty values. As a guiding principle, whenever no value was found for a certain year, country and indicator combination, it can be assumed that no value exists and as a consequence it got excluded in the analysis. A zero, on the other side means, the respective country received the lowest possible score within that year, and this value will be included in the analysis. After the empty values /

zeros verification, the data availability for each indicator and year was computed. The result shows whether there are missing countries for a certain indicator and year combination. Thus, 100% availability signifies a complete data availability, 0% means that not even one country has values for the selected year and indicator. Including Europa itself, 29 countries exist resulting in a 3.45% reduction for each country missing. Figure 6 shows exemplary several indicators and their data availability.

	A	B	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1	Country	Year	bb_speed	bb_speed	bb_speed	actspeed	price_inte	DESI_1D1_FBB	Price_Inte	Price_Inte	Afford_In	h_xcost	mbb_hsp	mbb_Itec	DESI_1B2	mob_sul
180	Slovenia	2013	0.44721442	0.05776018	0.0406366	0.8512	19.0821979				0.01435831	0.130754	0.99093901	0.63435528		2252
181	Slovenia	2014	0.51418952	0.10472888	0.06078727	0.81539084	22.7427848	0.015543017			0.01494265	0.111627	0.99372308	0.89655141		2322
182	Slovenia	2015	0.62624061	0.18091644	0.10109278			0.0170978			0.01697508	0.072591	0.99466208	0.97658427		2349
183	Slovenia	2016		0.241884				0.016505576				0.044456		0.936523		
184	Spain	2010	0.33521078	0.01608335	0.000081											55103
185	Spain	2011	0.5416691	0.10205477	0.01886226		43.6824562					0.10089	0.971	0		58298
186	Spain	2012	0.5416691	0.10205477	0.01886226	0.667	42.6409098					0.110312	0.96209498	0.12774548		57137
187	Spain	2013	0.56395509	0.14901024	0.05888754	0.6798	38.7299406				0.02565888	0.114657	0.99065824	0.47137116		55349
188	Spain	2014	0.91074111	0.23456827	0.10844856	0.73801498	39.7907604	0.027367116			0.02630656	0.092017	0.99654999	0.76346742		55697
189	Spain	2015	0.93310901	0.40932183	0.18884558			0.014200055			0.02689505	0.070613	0.99654999	0.79082543		55373
190	Spain	2016		0.48739				0.02427214				0.052596		0.859		
191	Sweden	2010	0.47634856	0.14442774	0.04420613											12204
192	Sweden	2011	0.52411041	0.18357167	0.16395078		22.0647739					0.019025	0.99640362	0.4813459		12997
193	Sweden	2012	0.66288457	0.28576435	0.2460284	0.686	13.8528285					0.019172	0.99688596	0.93257874		13684
194	Sweden	2013	0.73757021	0.37655497	0.3126774		17.6436981				0.00914023	0.021265	0.99672317	0.99194727		18900
195	Sweden	2014	0.79793062	0.52343275	0.38374924		20.6621875	0.006099453			0.00974896	0.026932	0.99068116	0.99166249		21470
196	Sweden	2015	0.83748212	0.59713877	0.46094421			0.007633457			0.00921397	0.015446	0.99068116	0.99166249		22664
197	Sweden	2016		0.628011				0.008300513				0.017932		0.999675		
198	Hungary	2010	0.40942683	0.14871149	0.01074099											10855
199	Hungary	2011	0.49035386	0.13722474	0.01509931		17.8314943					0.197749	0.913	0		11002
200	Hungary	2012	0.6095656	0.14109798	0.01539738	0.903	18.6479547					0.181144	0.95682622	0.35464556		10990
201	Hungary	2013	0.76009957	0.34320216	0.03918825		17.8795274				0.01702407	0.160966	0.97	0.39142909		11262
202	Hungary	2014	0.82880975	0.39616118	0.06403634	0.81340331	15.5705182	0.01646947			0.01599524	0.139343	0.98199184	0.73		11297
203	Hungary	2015	0.86489986	0.51477666	0.25867104			0.013477007			0.01566924	0.146036	0.9827965	0.95020602		11551
204	Hungary	2016		0.551832				0.01099845				0.10486		0.924		
205																
206	Data availability 2010		93.10%	93.10%	93.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	96.
207	Data availability 2011		96.55%	96.55%	96.55%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%	96.55%	96.55%	0.00%	96.
208	Data availability 2012		96.55%	96.55%	96.55%	75.86%	96.55%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%	0.00%	100.
209	Data availability 2013		96.55%	96.55%	96.55%	58.62%	100.00%	0.00%	0.00%	0.00%	93.10%	96.55%	100.00%	100.00%	0.00%	100.
210	Data availability 2014		100.00%	100.00%	100.00%	58.62%	100.00%	89.66%	0.00%	0.00%	93.10%	100.00%	100.00%	100.00%	0.00%	100.
211	Data availability 2015		100.00%	100.00%	100.00%	0.00%	0.00%	89.66%	0.00%	0.00%	93.10%	100.00%	100.00%	100.00%	0.00%	100.
212	Data availability 2016		0.00%	100.00%	0.00%	0.00%	0.00%	93.10%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%	0.00%	0.
213	**Data availability**		**83.25%**	**97.54%**	**83.25%**	**27.59%**	**56.65%**	**38.92%**	**0.00%**	**0.00%**	**39.90%**	**85.22%**	**70.94%**	**85.22%**	**0.00%**	**84.**

Figure 6: Computing Data Availability

Knowing the data availability for each indicator and year, it was possible to determine the data availability for concrete datasets (samples). As both longitudinal and cross section analyses have been performed, data availability for both kind of datasets were computed, which is explained in the next chapter.

3.6. Datasets

As described in the chapter before, the computation rule differed per type of analysis. This is due to the fact that different analyses require different kind of data. For the Panel data analysis, longitudinal data were used, that are, data for several consecutive years. Using the data availability obtained for each year and indicator combination (see Figure 6), in the following step it was required to find out how many indicators were included within a certain time range. Whether an indicator got included or not depends on its data availability score for all respective years. All in this case connotes, only if the data availability score of the indicator reaches the threshold (80%) in all years, it will be included, otherwise it will be scrapped. A score under the threshold in one or more years within the time range, results in its exclusion. Having said

that, the number of usable indicators was computed for a number of datasets, illustrated in Table 8. A similar procedure was applied to identify the potential number of indicators for the cluster analysis datasets. Instead of longitudinal data, this type of analysis requires a dataset with two years which will be contrasted, for instance 2010 with 2016. The threshold was again set to 80%, means only if the data availability score of the indicator was higher than 80% in both years, it got included.

Table 9 shows the number of indicators found for several years combinations required for the Cluster analysis. An 'x' highlights the time ranges that were shortlisted for the Panel data analysis. The deciding factors in order to select datasets were the following:

- Number of indicators included
- Coverage of all four DMI categories as well as the 8 under lying sub-categories
- End year distance to current year (the recent the better)

Table 8: Indicators identified for Panel Data Analysis

Longitudinal Dataset	*KPI's usable*	
2016-2010	28	
2016-2011	38	x
2016-2012	42	x
2016-2013	49	
2016-2014	58	
2015-2010	40	
2015-2011	53	x
2015-2012	58	
2015-2013	68	
2014-2010	46	x
2014-2011	60	
2014-2012	65	
2013-2010	59	x
2013-2011	73	

Table 9: Indicators identified for Cluster Analysis

Cluster Dataset	*KPI's usable*	
2016 & 2010	36	
2016 & 2011	43	
2016 & 2012	52	x
2016 & 2013	54	
2016 & 2014	64	x
2015 & 2010	56	
2015 & 2011	62	
2015 & 2012	66	
2015 & 2013	77	x
2014 & 2010	54	
2014 & 2011	66	x

The results show that for the Panel Data analysis as little as 28 up to 73 indicators could be found meeting the data availability requirement. Results for the Cluster analysis datasets were slightly better, with a minimum of 36 indicators and a maximum of 77. Not surprisingly, the number of indicators for a certain time range (e.g. 2010 – 2016) tends to be smaller as the number of indicators only for the beginning and end year (2010 & 2016). In a similar vein, the number of indicators for long time range (e.g. 2010 – 2016 ~6 years, 26 indicators) is smaller than the number of indicators for a short time range (e.g. 2013 – 2016 ~3 years, 49 indicators). Another observation that has been made is that the more recent the period is, the higher the data availability. The reason for this is that some indicators have not been collected in the earlier periods, with several indicators that have not even been collected before 2016. As the general aim was to use as recent data as possible, a cut off has been made for data that was discontinued before 2014. While indicators with only recent data (e.g. only 2016) is included

in the dataset, indicators discontinued before 2014 were not considered. There are also a number of indicator that discontinued in 2014. Thus, higher data availability can be expected in the future.

3.7. Data Analysis

This step aims to analyze the general structure of the dataset, evaluating its suitability to study the phenomenon defined in the theoretical framework and to determine subsequent methodological choices (e.g., weighting, aggregation).

All analyses have been performed with Stata, a statistical software for data analysis, data management, and graphical creation[10].

3.7.1. Factor Analysis

Factor analysis is a technique to reduce the dimensionality of the dataset by finding interrelations among those variables so that a smaller set of hypothetical variables (factors) can represent the whole dataset (Kim and Mueller, 1978).

For each selected dataset, factors have been formed to find single factors representing all categories and sub-categories of the theoretical framework. Hence, the objective was to identify and validate the underlying factors within each sub-category. Ideally, several variables within one sub-category, e.g. Infrastructure - enabling factors could be factorized to one factor and so contain all (or almost all) information regarding the specific sub-category.

Before performing factor analysis, the data is standardized producing a set of variables with a mean equal to 0 and a standard deviation of 1, an important prerequisite for the following analyses (see chapter 3.7.3). Standardizing the values ensures that the data is on the same scale, hence invariance to scale changes and displacement is obtained (Duda et al., 2012). Having standardized values, the actual factorization can begin. A factor analysis was performed for each set of enablers and achieved results, resulting ideally in one factor for each sub-category. However, this was not always possible as in some cases only few indicators were available or the factor loadings suggested two or more factors. The eigenvalue threshold is set to 1, so that a factor must have an eigenvalue greater than 1 to be retained. In some cases when the factor loadings suggested more than one factors, the eigenvalue was minimally adjusted, determining whether a small adjustment resulted in only one factor. After the factorization, the loading matrix was rotated by an oblique promax rotation, using a power of 3. With the rotated matrix, the final number of factors, their factor loadings and uniqueness can be investigated, providing

[10] For more information about the software, please visit https://www.stata.com

a first hint on the significance of the factor. A further hint will be provided with the scale reliability coefficient, also called Cronbach alpha value, which measures the internal consistency of a given list of variables (at least two), that is, or in other words how closely correlated a set of indicators are as a group. The value can range between 0 and 1. A value of 1 indicates high correlation, means factor loadings of all variables measured contribute roughly equal information to the Cronbach alpha score, while a low value highlights stark differences in the contributions, hence a low correlation among (some of) the variables. Ideally all factors have a reliability close to 1, however, that is not always given. Bernstein (1978) proposes a reliability of 0.90 as the minimum that should be tolerated. The threshold for the Cronbach Alpha value was set at > 0.85. In case of a low score, the factorization might be adjusted and the variable(s) that cause the low score eliminated. If all tests results are positive and there is a significant correlation among a set of variables, a new variable - the factor - will be created. In concrete terms, using the results of rotated factor matrix, the new created variable(s) contain predictions of the factors scored by the regression method.

The procedure delineated above will be repeated for each sub-category until all variables of one data-set have been factorized. In addition, all datasets used were factorized before entering sub-sequent analyses, including both Panel data and Cluster analysis. Result of the Factor analyses can be seen in Chapter 4.1.

3.7.2. Panel Data Analysis

Panel data, also called longitudinal data, is a set of data in which the behavior of entities, using the same units, are observed across several time periods (Kennedy, 2008). Panel data analysis investigates the correlation between predicting variables and outcome variable, either by a random or fixed effect method. In a nutshell, the fixed effect method controls for variables that cannot be observed or examined (e.g. cultural variety between countries), while the random effect method does not. In more technical words, if individual effects within the longitudinal data exists individual specific characteristics in the independent variable are not captured, hence a correlation between the predicting variable and outcome variable might be related to unobserved factors. The fixed effect method accounts for those individual specific characteristics that may influence the results, while random effect method assumes that individual effects are not correlated with any independent variables (Allison, 2009). Even though the fixed effect model is often seen as the preferred method, there are good reasons for using the random effect method (Bell and Jones, 2015). An appropriate method to select between fixed or random effect method is the Hausman specification test which compares a random effect model to its fixed counterpart (Hausman, 1978). The results found that the null

hypothesis, that is, individual effects are uncorrelated with the independent variables is rejected, hence a fixed effect model is favored. Further, it was checked for heteroscedasticity through the “modified Wald test for group wise heteroscedasticity in fixed effect regression model” (Christopher, 2000). The test indicated heteroscedasticity is present in most of the cases, which is why the robust option for running the panel data analysis was applied.
In addition, two control variables were added: “Doing Business Index” and “Rural Population”. This is necessary because of the possibility of factors that correlate with the DMI and its sub-categories, and thus bias the results. Panel data analysis was used to confirm (or refuse) the relationship between enabling factors and achieved results.

3.7.3. Cluster Analysis

Cluster Analysis can be defined as "the art of finding groups in data" (Kaufman and Rousseeuw, 2009). This somewhat flowery definition explains accurately the objective of performing a cluster analysis, that is, determining whether some countries behave in a similar fashion ant thus, can be grouped together. Building on the factorized datasets (see chapter xx for the full list of factors used, including a break-down of all indicators), a two-step clustering was performed, starting with a hierarchical clustering to select the number of clusters, followed by the k-means clustering method to break the observations into a mutually exclusive groups/clusters. This procedure was conducted on data of two years, allowing a comparison of the clusters between two periods in a final step.
As cluster analysis cannot handle missing values, it was decided to replace those values with a 0 to nullify the effect of the corresponding category as much as possible. Since values are standardized, a 0 represents exactly the mean of the factor and as a consequence, missing values are most probably determined only by their non-missing values. Alternatively, the country could have been dropped but this would exclude the country for the whole analysis.
A Ward’s linkage cluster analysis has been performed as clustering method (Ward, 1963), using the Euclidean distance. In order to determine the number of clusters the Calínski–Harabasz pseudo-F index has been used as stopping-rule, computing the index for the two-group cluster solution up to the ten-group cluster solution. Further insight about the number of clusters can be obtained through the Duda–Hart Je(2)/Je(1) index, where values are pseudo-T-squared values. Using both the Calínski–Harabasz pseudo-F index and the Duda–Hart Je(2)/Je(1) index, one can obtain a reasonable deduction about the number of clusters. The most appropriate number of clusters are characterized by large Calínski–Harabasz pseudo-F values, large Duda–Hart Je(2)/Je(1) values, and small Duda–Hart pseudo-T-squared values. As a rule of thumb in order to decide the right number of groups, a small set of Je(2)/Je(1) values

that corresponds to a low pseudo-T-squared value has to be identified. This set will then be compared with the Calínski–Harabasz results, selecting the number of clusters with the largest Calínski–Harabasz pseudo-F value. Next, k-means clustering method was applied, using the before obtained number of clusters (k) as the initial point for k-means. In an iterative process, each observation (here: country) gets assigned to the group whose mean is closest, determining also new group means. The process continues until no observations change groups. As the right number of clusters is often inconclusive, the k-means clustering method was performed with several number of groups, guided by the results of the before mentioned procedure (Calínski–Harabasz pseudo-F index and the Duda–Hart Je(2)/Je(1) index).

After the clusters are created, one-way analysis of variance (ANOVA) tests were performed to evaluate differences between the mean values of the identified clusters, using Scheffé's multiple-comparison test (Scheffé, 1953).

3.8. Links to other indexes

In order to improve the informative value but also robustness of a newly created composite index it is useful to examine correlations with existing indexes or single indicators as well as to identify relations through regressions.

In this study, the DMI was compared with three other indexes or indicators. A traditional and often used indicator is the GDP of a country, allowing to measure whether improvements in the DMI results in a higher GDP. Further advantages of this indicator are an almost complete set of data and the fact that a nation's GDP is an easy to understand indicator. As one of the most established indexes to measure the digital performance of a country, DESI was used as second comparable. Having already gained acceptance and been used several years, correlations with DESI gives the DMI more credibility and robustness. Lastly, the Doing Business index was correlated with DMI giving an additional view on the DMI results, that is, whether progressions on the digital maturity of a country lead to better chances of doing business in a country, illustrating how easy it is to find a job or start a business.

Correlations between those indicators and the DMI were identified by using a one-way ANOVA test, based on the clusters obtained in section 3.7.3. In other words, it was checked whether the differences between the DMI clusters (set of countries) are significant, by using one of the indicators / indexes described above.

4. Results

This chapter presents empirical evidence to fill the research gaps discovered in section 2.7 and to answer the research questions stated in 3.1. In particular, first results of the empirical analysis accept or reject the hypotheses stated in section 3.3.2 which drove the design of the DMI. Second, countries are grouped according to their digital performance. This grouping of countries highlights common patterns for countries that perform over average as well as under average.

4.1. A comprehensive Index to measure the Digital Maturity

As described in section 3.3.1 the composite index is composed by four domains, each including two sub-categories: enabling factor and achieved results. Following for each domain, the results of the Factor analysis is presented which states the indicator included for each sub-category. Next, Panel data results[11] are provided with the aim to confirm the correlation between enabling factors and achieved results and thus reject or do not reject the hypotheses stated in section 3.3.2 and summarized in Table 10.

Table 10: Summary of Hypotheses

Hypothesis	Description	Independent Variable	Dependent Variable
1	*Progress in Citizen Enabling Factors does influence positively the Achieved Results within the Citizen domain*	Citizen Enablers	Citizen Achieved Results
2	*Progress in Firm Enabling Factors does influence positively the Achieved Results within the Firm domain*	Firm Enablers	Firm Achieved Results
3	*Progress in Public Administration Enabling Factors does influence positively the Achieved Results within the Public Administration domain*	Public Administration Enablers	Public Administration Achieved Results
4	*Progress in Infrastructure Enabling Factors does influence positively the Achieved Results within the Infrastructure domain*	Infrastructure Enablers	Infrastructure Achieved Results
5	*Progress in Public Administration Enabling Factors does influence positively the Achieved Results within the Citizen domain*	Public Administration Enablers	Citizen Achieved Results
6	*Progress in Public Administration Achieved Results does influence positively the Achieved Results within the Firm domain*	Public Administration Achieved Results	Firm Achieved Results

Following, domains are presented separately, starting with the factors obtained of each sub-category (enablers and achieved results) of the domain. Next, the results of the panel data analysis corresponding to the specific domain is shown, rejecting or not rejecting the hypotheses stated. Occasionally, some further links have been found which are mentioned in addition.

[11] 13 models have been created of which 4 are presented in this chapter. More details regarding all models of the Panel data analysis can be retrieved from Annex V: Complete Panel Data results. Furthermore, Annex IV: Panel Results STATA provides additional statistical insights.

4.1.1. Citizen Domain

There is almost no variation between all datasets for the Citizen enabling factors. In fact, the factor consists of the same indicators for three of the four datasets (except the dataset for the period 2010 – 2013). The Cronbach alpha value is acceptable for all factors, ranging from 0.8968 to 0.9386, indicating significant scale reliability for all factors (see Table 11).

Table 11: Factors - Citizen Enablers

	2011 - 2016		2012 - 2016		2011 - 2015		2010 - 2013	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Citizen Enablers		0.8968		0.907		0.9045	Households with computer	0.9386
	Households with access to the Internet at home		Households with access to the Internet at home		Households with access to the Internet at home		Households with access to the Internet at home	
	Secure Internet servers		Secure Internet servers		Secure Internet servers		Secure Internet servers	

Table 12 illustrates a larger variation for the achieved results factors. Noteworthy is the higher number of indicators for the dataset 2010-2013. This is expected, as mentioned in chapter 3.6, and due to the higher data availability of those datasets. The Cronbach alpha values are even higher compared to the values of the enabling factors, thus it exists a significant scale reliability for all factors (lowest: 0.9634; highest: 0.9710). The indicator "Individuals who have never used the internet" is reversed, means the lower the value the better the country ranks.

Table 12: Factors – Citizen Achieved Results

	2011 - 2016		2012 - 2016		2011 - 2015		2010 - 2013	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Citizen Achieved results	Reading / downloading online newspapers / news magazines	0.9664	Reading / downloading online newspapers / news magazines	0.9658	Reading / downloading online newspapers / news magazines	0.9736	Reading / downloading online newspapers / news magazines	0.9741
					ICT Access - Computer Ownership		ICT Access - Computer Ownership	
							Diversification index for the activities realised online by internet users	
	Individuals using a laptop/tablet to access the internet, away from home or work		Individuals using a laptop/tablet to access the internet, away from home or work		Individuals using a laptop/tablet to access the internet, away from home or work		Individuals using a laptop/tablet to access the internet, away from home or work	
	Individuals who are frequent internet users (every day or almost every day)		Individuals who are frequent internet users (every day or almost every day)		Individuals who are frequent internet users (every day or almost every day)		Individuals who are frequent internet users (every day or almost every day)	
	Individuals who are regular internet users (at least once a week)		Individuals who are regular internet users (at least once a week)		Individuals who are regular internet users (at least once a week)		Individuals who are regular internet users (at least once a week)	
	Individuals who have never used the internet*		Individuals who have never used the internet*		Individuals who have never used the internet*		Individuals who have never used the internet*	
	Individuals who have used internet in the last 12 months		Individuals who have used internet in the last 12 months		Individuals who have used internet in the last 12 months		Individuals who have used internet in the last 12 months	
	Individuals who have used internet in the last 3 months		Individuals who have used internet in the last 3 months		Individuals who have used internet in the last 3 months		Individuals who have used internet in the last 3 months	
	Looking for information about goods and services online		Looking for information about goods and services online		Looking for information about goods and services online		Looking for information about goods and services online	
	Telephoning or video calls (via webcam) over the internet		Telephoning or video calls (via webcam) over the internet				Telephoning or video calls (via webcam) over the internet	
	Using online banking		Using online banking		Using online banking		Using online banking	

* Reversed item

Verification of the Hypotheses

Model 2 has been selected to provide evidence to hypothesis 1 and 5. The observation included 26 countries and a sample size of 79. The 2011-2015 dataset was used and the R^2 value is 0.5247 (see Table 13). In choosing the independent variables, a one year lag was considered, anticipating the delay until an effect can be observed.

Table 13: Panel Data - Citizen Achieved Results

	Dataset	2011-2015
	Countries	26
	Sample	79
	Model ID	2
	Model type	Fixed Effect
	R-sq.	0.5247
	Dependent variable	Citizen A
Independent variable	Citizen E	NA
	Firm E	NA
	Public admin E	NA
	Infstr E	NA
	Citizen E (previous Year)	0.4645*** (0.1587)
	Firm E (previous Year)	0.0142 (0.0686)
	Public Admin E (previous Year)	0.1601** (0.707)
	Infstr E (previous Year)	0.0726* (0.0396)
	Citizen A	NA
	Firm A	NA
	Public admin A	NA
	Infstr A	NA
	Citizen A (previous Year)	NA
	Firm A (previous Year)	0.0142 (0.0659)
	Public Admin A (previous Year)	-0.1594** (0.0659)
	Infstr A (previous Year)	IA1: -0.0450, IA1(0.0749), IA2: 0.1150 IA2(0.1087)
	Cntrl_var Doing Business	0.0343 (0.0464)
	Cntrl_Var Rural Pop	-1.5800 (1.1365)

N/A: Not included in the model, * P-Value < 0.1, ** P-Value < 0.05, *** P-Value < 0.01

Robust Standard Errors in parentheses

Improvements made in Citizen enabling factors have a big impact on achieved results and a p-value of 0.007, hence hypothesis 1 is supported. As described in 3.3.2, Citizen Achieved results represent indicators measuring the ICT adoption, especially the usage of internet, of citizens for several purposes. The Panel data results suggests that improvement for the two enabling factors “Households with access to the Internet at home” and “Secure Internet servers” results in a higher adoption of ICT for a country’s citizens.

Moreover, hypothesis 5 is supported as well, with a p value of 0.032. Driving indicator within the Public Administration enablers is “Internet access in school”, implying schools that have internet access lead to a higher ICT adoption even outside of the school and so raising the score for a nation’s citizens.

In addition, enabling factors of the Infrastructure do also influence Citizen's achieved results, but with a smaller impact, having found a p-value of 0.078. The indicators in the model used are related to broadband coverage of both fixed and mobile broadband. This might suggest, without the right infrastructure in terms of broadband coverage, citizen cannot improve their ICT adoption. Lastly, the analysis found a negative impact for previous' year Public Administration Achieved results on Citizens Achieved results, with a p-value of 0.023. This finding suggests, advancements made in Public Administration influences negatively the Citizen Achieved results.

4.1.2. Firm Domain

All four factors have an acceptable Cronbach alpha value, with at least 0.8433 and up to 0.9096 (see Table 14). However, dataset 2011-2015 shows the lowest Cronbach alpha but includes one additional indicator "Persons Employed with ICT Specialist Skills (broad measure)". Removing the indicator pushes the Cronbach alpha value to 0.9039. In fact, with a factor loading value of 0.2125 and uniqueness of 0.9548, there are further good reasons to drop the indicator. In this case the decision made was to maintain it, as the reliability of 0.8433 is still high and the indicator itself offers valuable insights, adding a critical enabling factor for firms, that is, employing ICT specialists.

Table 14: Factors - Firm Enablers

	2011 - 2016		2012 - 2016		2011 - 2015		2010 - 2013	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Firm Enablers	Persons employed using computers with access to the Web at work (business sector)	0.8944	Persons employed using computers with access to the Web at work (business sector)	0.9096	Persons employed using computers with access to the Web at work (business sector)	0.8446	Persons employed using computers with access to the Web at work (business sector)	0.8433
	Enterprises providing portable devices to more than 20% of their employed persons		Enterprises providing portable devices to more than 20% of their employed persons		Enterprises providing portable devices to more than 20% of their employed persons			
	Persons employed which were provided a portable device by their employer (business sector)		Persons employed which were provided a portable device by their employer (business sector)		Persons employed which were provided a portable device by their employer (business sector)			
	Enterprises using any computer network for sales (at least 1%)		Enterprises using any computer network for sales (at least 1%)		Enterprises using any computer network for sales (at least 1%)		Enterprises using any computer network for sales (at least 1%)	
							Business R&D expenditure of the ICT sector	
							Employment of the ICT sector	
					Persons Employed with ICT Specialist Skills (broad measure)		Persons Employed with ICT Specialist Skills (broad measure)	
	Enterprises providing portable devices to some of their persons employed		Enterprises providing portable devices to some of their persons employed		Enterprises providing portable devices to some of their persons employed			
							Total investment in networks by the electronic communications sector	

The observation in Table 15 shows the first sub category with two factors, used in the dataset 2010-2013. The factor analysis clearly suggested two factors and did not find a significant correlation between the two indicators "Value added of the ICT sector" and "Total revenues of the electronic communications sector" and the remaining set of indicators. As a consequence, two factors were created; FA1 which includes the first seven indicators, and FA2 including the two indicators mentioned before. It got confirmed through two Cronbach alpha values over 0.9, especially the second factor received a very high reliability of 0.9871.

Table 15: Factors - Firm Achieved Results

	2011 - 2016		2012 - 2016		2011 - 2015		2010 - 2013	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Firm Achieved results	Enterprises having a web site or homepage	0.9425	Enterprises having a web site or homepage	0.9403	Enterprises having a web site or homepage	0.9412	Enterprises having a web site or homepage	FA1: 0.908
	Individuals ordering content or software delivered online or offline		Individuals ordering content or software delivered online or offline		Individuals ordering content or software delivered online or offline		Individuals ordering content or software delivered online or offline	
	Individuals ordering goods or services online		Individuals ordering goods or services online		Individuals ordering goods or services online		Individuals ordering goods or services online	
	Individuals ordering goods or services online, from sellers from other EU countries		Individuals ordering goods or services online, from sellers from other EU countries		Individuals ordering goods or services online, from sellers from other EU countries		Individuals ordering goods or services online, from sellers from other EU countries	
	Individuals ordering physical goods online		Individuals ordering physical goods online		Individuals ordering physical goods online			
	Individuals ordering services online		Individuals ordering services online		Individuals ordering services online			
	Individuals selling goods or services online (e.g. via auctions)		Individuals selling goods or services online (e.g. via auctions)		Individuals selling goods or services online (e.g. via auctions)		Individuals selling goods or services online (e.g. via auctions)	
	Total electronic sales by enterprises, as a % of their total turnover		Total electronic sales by enterprises, as a % of their total turnover		Total electronic sales by enterprises, as a % of their total turnover		Total electronic sales by enterprises, as a % of their total turnover	
							Labour productivity of the ICT sector (per person)	
							Value added of the ICT sector	FA2: 0.9871
							Total revenues of the electronic communications sector	

Verification of the Hypotheses

Model 9 has been selected to investigate hypothesis 2 and 6. The performance of 25 countries have been measured. Dataset 2012 – 2016 was used, with 82 observations and the obtained R^2 value is 0.0356.

Hypothesis 2 got strongly confirmed by the results of the Panel data analysis with a p-value of 0.007. In order to improve the achieved results of a firm, the results suggest to equip employees with both a computer with internet access and a portable device. Further, the results show correlation between Citizen enabling factors and Firm achieved results through a p-value of 0.085. This means, for individuals with a higher ICT adoption in private, ICT tends to play an important role in their business life as well.

Moreover, there is also strong evidence that Public Administration's achieved results do influence the Firm achieved results, with a p-value of 0.032. This finding is in line with

hypothesis 5 as individuals who are more technically inclined tend do use ICT not only for private purposes but also in a professional context. Further support comes from the fact that Citizen's enabling factor influences Firm's achieved result as well, receiving a p-value of 0.085.

Table 16: Panel Data - Firm Achieved Results

	Dataset	2012-2016	
	Countries	25	
	Sample	82	
	Model ID	9	
	Model type	Fixed Effect	
	R-sq.	0.0356	
	Dependent variable	Firm A	
Independent variable	Citizen E	NA	
	Firm E	NA	
	Public admin E	NA	
	Infstr E	NA	
	Citizen E (previous Year)	0.3570*	(0.1989)
	Firm E (previous Year)	0.1610***	(0.0549)
	Public Admin E (previous Year)	-0.0846	(0.1104)
	Infstr E (previous Year)	-0.0131	(0.0551)
	Citizen A	-0.0244	(0.1403)
	Firm A	NA	
	Public admin A	0.2991**	-0.1335
	Infstr A	0.1384	(0.1166)
	Citizen A (previous Year)	NA	
	Firm A (previous Year)	NA	
	Public Admin A (previous Year)	NA	
	Infstr A (previous Year)	NA	
	Cntrl_var Doing Business	-0.0824	(0.0749)
	Cntrl_Var Rural Pop	1.0210	(1.4492)

N/A: Not included in the model, * P-Value < 0.1, ** P-Value < 0.05, *** P-Value < 0.01

Robust Standard Errors in parentheses

4.1.3. Public Administration domain

Table 17 highlights one of the main reasons why the dataset 2010-2013 was included. In all other datasets only few, if any, indicators were considered after the data cleaning conducted (see chapter 3.6). Dataset 2010-2013 on the other side included eight indicators, allowing a more comprehensive analysis on the public administration domain. On the other side, two indicators that were included in the 2012 – 2016 dataset before, were dropped ("Importance of ICTs to government vision of the future" and "Laws relating to ICTs"). Cronbach alpha values are significant for all factors. It is important to note that dataset 2011 – 2016 does not include any indicators and dataset 2011 – 2015 includes only one standalone variable ("internet access in school"), an indicator not represented in any other factor.

Table 17: Factors - Public Administration Enablers

	2011 - 2016		2012 - 2016		2011 - 2015		2010 - 2013	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Public Administration Enablers			Importance of ICTs to government vision of the future	0.9447		n/a		0.8843
			Laws relating to ICTs					
							Average EC funding per participation in FP7-ICT projects	
							EC funding to participants in FP7-ICT projects	
							FP7 EC effective cofinancing rate	
							GBAORD - Government budget appropriations or outlays for research and development	
							Number of distinct organisations participating in FP7-ICT projects	
							Number of distinct organisations participating in FP7-ICT projects for the first time	
							Total cost of FP7-ICT projects	
							Total number of participations in FP7-ICT projects	
					Internet access in schools**			

** Standalone Variable

The Factor analysis suggested one factor for each dataset. Cronbach alpha values were acceptable and ranged from 0.7058 as the lowest value to 0.8766 as the highest one, encouraging to keep all indicators as one factor. Conversely to the observation made before, dataset 2010-2013 included this time the least variables. Table 18 shows the factors and indicators included.

Table 18: Factors - Public Administration Achieved Results

	2011 - 2016		2012 - 2016		2011 - 2015		2010 - 2013	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Public Administration Achieved results	Government effectiveness	0.7058	Government effectiveness	0.8766	Government effectiveness	0.7078	Government effectiveness	0.8503
			ICT use and government efficiency					
			Impact of ICTs on access to basic services					
	Individuals interacting online with public authorities, last 12 months		Individuals interacting online with public authorities, last 12 months		Individuals interacting online with public authorities, last 12 months		Individuals interacting online with public authorities, last 12 months	
	Individuals submitting completed forms to public authorities, over the internet, last 12 months		Individuals submitting completed forms to public authorities, over the internet, last 12 months		Individuals submitting completed forms to public authorities, over the internet, last 12 months			

Verification of the Hypotheses

Model 13 has been selected to investigate hypothesis 3. This model includes 23 countries, resulting in 60 observations. This is the lowest number of observations among the models. The R^2 value is 0.1296 and the dataset used is 2010 – 2013.

Table 19 shows no significant correlations exist between the dependent and any independent variable, thus hypothesis 3 is not supported by the model.

Table 19: Panel Data - Public Administration Achieved Results

	Dataset	2010-2013	
	Countries	23	
	Sample	60	
	Model ID	13	
	Model type	Fixed Effect	
	R-sq.	0.1296	
	Dependent variable	Public admin A	
Independent variable	Citizen E	NA	
	Firm E	NA	
	Public admin E	NA	
	Infstr E	NA	
	Citizen E (previous Year)	-0.4058	(0.4267)
	Firm E (previous Year)	-0.2420	(0.3852)
	Public Admin E (previous Year)	-0.1899	(0.3595)
	Infstr E (previous Year)	IE1: 0.1046, IE2: -0.0492	IE1(0.1674), IE2(0.2041)
	Citizen A	NA	
	Firm A	NA	
	Public admin A	NA	
	Infstr A	NA	
	Citizen A (previous Year)	NA	
	Firm A (previous Year)	NA	
	Public Admin A (previous Year)	NA	
	Infstr A (previous Year)	NA	
	Cntrl_var Doing Business	-0.0763	(0.2454)
	Cntrl_Var Rural Pop	-2.8608	(1.6802)

N/A: Not included in the model, * P-Value < 0.1, ** P-Value < 0.05, *** P-Value < 0.01

Robust Standard Errors in parentheses

4.1.4. Infrastructure domain

Factor analysis suggested one factor for each dataset. This finding is questioned by a Cronbach alpha values slightly lower as the set threshold, for all identified factors (see Table 20). However, dropping further indicators was ruled out and the scale reliability accepted. Even though the statistical significance is not particularly high, theory provides strong arguments that those indicators ("NGA broadband coverage/availability", "Standard fixed broadband coverage/availability", and "4G mobile broadband (LTE) coverage") represent initial factors for ICT improvement and are important factors for policymakers. According to Sawyer et al. (2003), "broadband (Internet) connectivity is seen by governments in many countries as an important means of increasing the international competitiveness of their country" and South Korea's leading position in the ICT domain stems from its position as "the world's broadband leader" (Choudrie and Lee, 2004).

Another particularity is presented by the 2010-2013 dataset which has two standalone variables instead of a factor. This is due to the fact that not all indicators have data for 2010. For instance, the three indicators mentioned before do not have 2010 data, but start with 2011. Being a standalone variable, the Cronbach alpha cannot be determined, since at least two variables must be specified.

Table 20: Factors - Infrastructure Enablers

	2011 - 2016		2012 - 2016		2011 - 2015		2010 - 2013	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Infrastructure Enabler		0.5455		0.5066	New entrants' share in fixed broadband subscriptions	0.679	New entrants' share in fixed broadband subscriptions**	n/a
	NGA broadband coverage/availability (as a % of households)		NGA broadband coverage/availability (as a % of households)		NGA broadband coverage/availability (as a % of households)			
					Rural standard fixed broadband coverage (as a % of households)			
	Standard fixed broadband coverage/availability (as a % of households)		Standard fixed broadband coverage/availability (as a % of households)		Standard fixed broadband coverage/availability (as a % of households)			
	4G mobile broadband (LTE) coverage (as a % of households)		4G mobile broadband (LTE) coverage (as a % of households)		4G mobile broadband (LTE) coverage (as a % of households)			n/a
					Advanced 3G mobile broadband (HSPA) coverage (as a % of households)			
							Mobile roaming price per minute**	

** Standalone Variable

Table 21 shows that almost all factors received Cronbach alpha values over 0.85, with 0.8512 the lowest value and 0.9121. However, the Factor analysis for the datasets 2011-2015 & 2010-2013 suggested three factors, that has been named IA1, IA2 and IA3. IA1 includes all indicators showing the share of fixed broadband subscriptions, differencing only through the advertised download speed. The scale reliability coefficient is acceptable with 0.7677 & 0.7563 and it does make sense to represent those indicators as one group as they all relate to fixed broadband subscriptions. IA2 has a Cronbach alpha of 0.9121 & 0.8724, indicating high scale reliability in both datasets. IA3 represents a similar situation as IA1 with one factor and acceptable Cronbach alpha values of 0.6911 & 0.6261. Similar to the IA1 case before, the factor was retained, as all indicators can be related to the take up of mobile broadband. The indicator "Market share of leading operator (in % of active SIM cards)" is reversed, implying low values are preferred. This is in line with theory, as 1 would be a monopoly and a low value can be interpreted as a low concentrated market, hence high competition resulting in lower prices for end consumer.

Table 21: Factors - Infrastructure Achieved Results

	2011 - 2016		2012 - 2016		2011 - 2015		2010 - 2013	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Infrastructure Achieved results	Households that have no access to Internet at home, because the costs are too high	0.873	Households that have no access to Internet at home, because the costs are too high	0.8512		IA1: 0.7677		IA1: 0.7563
					Share of fixed broadband subscriptions >= 10 Mbps - Advertised download speed		Share of fixed broadband subscriptions >= 10 Mbps - Advertised download speed	
					Share of fixed broadband subscriptions >= 100 Mbps - Advertised download speed		Share of fixed broadband subscriptions >= 100 Mbps - Advertised download speed	
					Share of fixed broadband subscriptions >= 2 Mbps - Advertised download speed		Share of fixed broadband subscriptions >= 2 Mbps - Advertised download speed	
	Share of fixed broadband subscriptions >= 30 Mbps - Advertised download speed		Share of fixed broadband subscriptions >= 30 Mbps - Advertised download speed		Share of fixed broadband subscriptions >= 30 Mbps - Advertised download speed		Share of fixed broadband subscriptions >= 30 Mbps - Advertised download speed	
	Enterprises having a fixed broadband connection		Enterprises having a fixed broadband connection		Enterprises having a fixed broadband connection	IA2: 0.9121	Enterprises having a fixed broadband connection	IA2: 0.8724
							Fixed broadband subscriptions	
					Fixed broadband take-up (subscriptions/100 people)		Fixed broadband take-up (subscriptions/100 people)	
	Households having a broadband connection		Households having a broadband connection		Households having a broadband connection		Households having a broadband connection	
	Households with fixed broadband connection		Households with fixed broadband connection		Households with fixed broadband connection		Households with fixed broadband connection	
	Individuals accessing the Internet through a mobile phone via UMTS (3G)		Individuals accessing the Internet through a mobile phone via UMTS (3G)		Individuals accessing the Internet through a mobile phone via UMTS (3G)	IA3: 0.6911	Individuals accessing the Internet through a mobile phone via UMTS (3G)	IA3: 0.6261
					Market share of leading operator (in % of active SIM cards)*		Market share of leading operator (in % of active SIM cards)*	
					Take-up of mobile - active SIM cards for voice or data		Take-up of mobile - active SIM cards for voice or data	
	Take-up of mobile broadband (subscriptions/100 people)		Take-up of mobile broadband (subscriptions/100 people)		Take-up of mobile broadband (subscriptions/100 people)		Take-up of mobile broadband (subscriptions/100 people)	
							Total number of subscriptions (SIM cards)	

* Reversed item

Verification of the Hypotheses

Model 7 has been selected to probe hypothesis 4. Model 7 includes all 28 countries and 104 observations. The R^2 value is 0.7763 and the dataset used is 2011 – 2016, (see Table 22).

A p-value of 0.040 supports hypothesis 4 and provides evidence that enhancements in the coverage of broadband lead to a higher ICT adoption of households and firms. Another enabling factor that influences the achieved results of Infrastructure is the Firm enabling factor with a p-value of 0.050. It implies, enterprises that equips its employees with ICT hardware tends to use ICT infrastructure at a greater extent.

Further, strong significance between Citizen's achieved results and Infrastructure's achieved results was found, receiving a p-value of 0.000. Hence, individuals who have ICT skills obtained show high ICT adoption. Similar assumptions hold for Firms, as the results showed

an association between Firm's achieved results and Infrastructure with a p-value of 0.072. In addition, with p-value of 0.012, Public Administration's achieved results correlate negatively with Infrastructure Achieved results. That finding is similar to the correlation observed between Public administration and the negative impact on Citizen's Achieved results.
Lastly, the control variable "Rural population" showed a negative effect and a correlation with a p-value of 0.097. It implies, the higher the value of rural population the less advancement in Infrastructure achieved results is made. In other words, rural areas tend to have less broadband coverage than urban areas.

Table 22: Panel Data - Infrastructure Achieved Results

	Dataset	2011-2016
	Countries	28
	Sample	104
	Model ID	7
	Model type	Fixed Effect
	R-sq.	0.7763
	Dependent variable	Infrastructure A
Independent variable	Citizen E	NA
	Firm E	NA
	Public admin E	NA
	Infstr E	NA
	Citizen E (previous Year)	0.3120 (0.3080)
	Firm E (previous Year)	0.2258* (0.1103)
	Public Admin E (previous Year)	NA
	Infstr E (previous Year)	0.1308** (0.0608)
	Citizen A	NA
	Firm A	NA
	Public admin A	NA
	Infstr A	NA
	Citizen A (previous Year)	0.4849*** (0.1174)
	Firm A (previous Year)	0.2941* (0.1570)
	Public Admin A (previous Year)	-0.1929** (0.0712)
	Infstr A (previous Year)	NA
	Cntrl_var Doing Business	0.0331 (0.1232)
	Cntrl_Var Rural Pop	-0.9743* (0.5661)

N/A: Not included in the model, * P-Value < 0.1, ** P-Value < 0.05, *** P-Value < 0.01
Robust Standard Errors in parentheses

4.2. Performance of the EU Member States

The results of chapter 4.1 provide empirical evidence that underlying assumptions are correct and the DMI can be used in the following step to shed light on the country's performances.
Following, countries are grouped according to their performance, identifying top performers and the factors that drove their performance. Also, the other side of the spectrum is analyzed by identifying low performers and the corresponding factors that dragged the country

downwards. Finally, by comparing two time periods, patterns of countries that improved can be investigated and key success factors determined.

This chapter proceeds as follows, in the first step results of the factor analyses are represented showing the underlying structure of this analysis. Second, the right number of groups is detected, the cluster analysis is performed and the found clusters are presented. In the third and last step, multiple-comparable tests are performed between clusters and outside variables to identify whether clusters are significantly different.

4.2.1. Identification of Factors and Number of clusters

Similar to the results of the Panel data analysis shown before, factors have been created based on the datasets created in section 3.6.

Citizen Domain

There are two indicators included in enabling factors and 13 indicators within the achieved results (see Table 23). Cronbach alpha ranges from 0.9124 as the lowest to 0.9669 as the highest value, showing throughout high scale reliability. One indicator “individuals who have never used the internet” is reversed, indicating the lower the value the better.

Table 23: Factors Citizen Domain - Cluster Analysis

2012			2016	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Citizen Enablers	Households with access to the Internet at home	0.9130	Households with access to the Internet at home	0.9124
	Secure Internet servers		Secure Internet servers	
Citizen Achieved results	Playing or downloading games, images, films or music	0.9634	Playing or downloading games, images, films or music	0.9669
	Reading / downloading online newspapers / news magazines		Reading / downloading online newspapers / news magazines	
	Individuals who have written a computer program using a specialised programming language		Individuals who have written a computer program using a specialised programming language	
	Individuals using a laptop/tablet to access the internet, away from home or work		Individuals using a laptop/tablet to access the internet, away from home or work	
	Individuals who are frequent internet users (every day or almost every day)		Individuals who are frequent internet users (every day or almost every day)	
	Individuals who are regular internet users (at least once a week)		Individuals who are regular internet users (at least once a week)	
	Individuals who have never used the internet*		Individuals who have never used the internet*	
	Individuals who have used internet in the last 12 months		Individuals who have used internet in the last 12 months	
	Individuals who have used internet in the last 3 months		Individuals who have used internet in the last 3 months	
	Looking for information about goods and services online		Looking for information about goods and services online	
	Telephoning or video calls (via webcam) over the internet		Telephoning or video calls (via webcam) over the internet	
	Uploading self-created content to be shared		Uploading self-created content to be shared	
	Using online banking		Using online banking	

* Reversed item

Firm Domain

Table 24 shows fairly balanced amount indicators for each sub-category. Enabling factors are composed of 10 indicators, while Achieved results consist of eight indicators. Cronbach alpha values are high, with none lower than 0.9, indicating high scale reliability.

Table 24: Factors Firm Domain - Cluster Analysis

2012			2016	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Firm Enablers	Persons employed using computers with access to the Web at work (business sector)	0.9095	Persons employed using computers with access to the Web at work (business sector)	0.9286
	Enterprises providing persons employed a remote access to the enterprise's e-mail system, documents or applications		Enterprises providing persons employed a remote access to the enterprise's e-mail system, documents or applications	
	Enterprises providing portable devices to more than 20% of their employed persons		Enterprises providing portable devices to more than 20% of their employed persons	
	Enterprises using mobile Internet to run business applications		Enterprises using mobile Internet to run business applications	
	Persons employed which were provided a portable device by their employer (business sector)		Persons employed which were provided a portable device by their employer (business sector)	
	Enterprises using any computer network for sales (at least 1%)		Enterprises using any computer network for sales (at least 1%)	
	Enterprise provided training to their personnel to develop/upgrade their ICT skills		Enterprise provided training to their personnel to develop/upgrade their ICT skills	
	Enterprises employing ICT specialists		Enterprises employing ICT specialists	
	Enterprises reporting hard-to-fill vacancies for jobs requiring ICT specialist skills		Enterprises reporting hard-to-fill vacancies for jobs requiring ICT specialist skills	
	Enterprises providing portable devices to some of their persons employed		Enterprises providing portable devices to some of their persons employed	
Firm Achieved results	Enterprises having a web site or homepage	0.9499	Enterprises having a web site or homepage	0.9284
	Individuals ordering content or software delivered online or offline		Individuals ordering content or software delivered online or offline	
	Individuals ordering goods or services online		Individuals ordering goods or services online	
	Individuals ordering goods or services online, from sellers from other EU countries		Individuals ordering goods or services online, from sellers from other EU countries	
	Individuals ordering physical goods online		Individuals ordering physical goods online	
	Individuals ordering services online		Individuals ordering services online	
	Individuals selling goods or services online (e.g. via auctions)		Individuals selling goods or services online (e.g. via auctions)	
	Total electronic sales by enterprises, as a % of their total turnover		Total electronic sales by enterprises, as a % of their total turnover	

Public Administration Domain

As can be seen in Table 25, Enabling factors are a bit underrepresented with only two indicators, while Achieved results include seven indicators. Scale reliability is given by high Cronbach alpha values for all factors.

Table 25: Factors Public Administration – Cluster Analysis

2012			2016	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Public Administration Enablers	Importance of ICTs to government vision of the future	0.9492	Importance of ICTs to government vision of the future	0.9591
	Laws relating to ICTs		Laws relating to ICTs	
Public Administration Achieved results	E Participation Index	0.9232	E Participation Index	0.9131
	Government effectiveness		Government effectiveness	
	ICT use and government efficiency		ICT use and government efficiency	
	Impact of ICTs on access to basic services		Impact of ICTs on access to basic services	
	Individuals interacting online with public authorities, last 12 months		Individuals interacting online with public authorities, last 12 months	
	Individuals submitting completed forms to public authorities, over the internet, last 12 months		Individuals submitting completed forms to public authorities, over the internet, last 12 months	
	Making an appointment with a practitioner via a website		Making an appointment with a practitioner via a website	

Infrastructure Domain

There are three indicators included in enabling factors and seven indicators within the achieved results (see Table 26). Especially for the 2012 dataset the Cronbach alpha value is particularly low. However, as already stated in section 4.1.4 theory provides strong arguments to keep those indicators together. It is worth pointing out that the 2016 value, for the same indicators, is many times higher suggesting an existing scale reliability nonetheless. Factors within the Achieved Results received high Cronbach alpha values.

Table 26: Factors Infrastructure – Cluster Analysis

2012			2016	
Category	**Indicator**	**Alpha**	**Indicator**	**Alpha**
Infrastructure Enabler	NGA broadband coverage/availability (as a % of households)	0.0182	NGA broadband coverage/availability (as a % of households)	0.5758
	Standard fixed broadband coverage/availability (as a % of households)		Standard fixed broadband coverage/availability (as a % of households)	
	4G mobile broadband (LTE) coverage (as a % of households)		4G mobile broadband (LTE) coverage (as a % of households)	
Infrastructure Achieved results	Households that have no access to Internet at home, because the costs are too high*	0.9095	Households that have no access to Internet at home, because the costs are too high*	0.8512
	Share of fixed broadband subscriptions >= 30 Mbps - Advertised download speed		Share of fixed broadband subscriptions >= 30 Mbps - Advertised download speed	
	Enterprises having a fixed broadband connection		Enterprises having a fixed broadband connection	
	Households having a broadband connection		Households having a broadband connection	
	Households with fixed broadband connection		Households with fixed broadband connection	
	Individuals accessing the Internet through a mobile phone via UMTS (3G)		Individuals accessing the Internet through a mobile phone via UMTS (3G)	
	Take-up of mobile broadband (subscriptions/100 people)		Take-up of mobile broadband (subscriptions/100 people)	

* Reversed item

Number of Clusters

Once factors have been found, the number of clusters could be determined. Based on the reasoning of the process described in section 3.7.3, a three-cluster solution satisfied all criteria for both years best, showing consistency throughout the years. Four clusters have been tried as well, but results for three clusters showed a clearer separation and more significant differences.

Table 27: Result - Number of Clusters for 2012 & 2016

	2012			2016		
Number of clusters	Calínski–Harabasz pseudo-F	Duda-Hart		Calínski–Harabasz pseudo-F	Duda-Hart	
		Je(2)/Je(1)	Pseudo-T-squared		Je(2)/Je(1)	Pseudo-T-squared
2	41.700	0.401	16.450	38.040	0.491	14.520
3	**35.340**	**0.682**	**6.070**	**32.610**	**0.514**	**8.510**
4	31.160	0.488	8.390	31.040	0.627	7.140
5	29.130	0.454	6.010	30.320	0.168	14.840
6	27.350	0.544	2.510	32.030	0.421	9.620
7	26.160	0.520	3.690	36.600	0.511	3.830
8	25.240	0.403	2.960	36.690	0.356	5.430
9	24.910	0.053	17.750	37.370	0.372	3.380
10	24.460	0.625	3.000	36.640	0.000	0.000

4.2.2. Cluster 2012

The three clusteres obtained were categorized as low, middle and high, representing groups of countries that performed jointly low, mediocre or high.

Table 28: Results Cluster Analysis 2012

2012							
Cluster	**Countries**	**Category**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Cluster High	**Sweden, Denmark, Netherlands, United Kingdom, Luxembourg, Finland**	C_Achieved_Z	6	1.5220	0.2918	0.9875	1.8510
		F_Achieved_Z	6	1.2024	0.6593	0.0000	1.8445
		P_Achieved_Z	6	1.2932	0.5661	0.5906	1.9564
		I_Achieved_Z	6	1.4894	0.2875	0.9518	1.7862
Cluster Middle	**Germany, Malta, Austria, Slovenia, Estonia, Spain, Ireland, France, Belgium**	C_Achieved_Z	9	0.1317	0.3531	-0.3780	0.5393
		F_Achieved_Z	9	0.2579	0.5920	-0.6531	1.2253
		P_Achieved_Z	9	0.3792	0.3535	-0.1565	0.8947
		I_Achieved_Z	9	0.1831	0.3245	-0.1930	0.6582
Cluster Low	**Slovakia, Hungary, Romania, Croatia, Lituania, Bulgaria, Italy, Portugal, Czech Republic, Greece, Latvia, Cyprus, Poland**	C_Achieved_Z	13	-0.7893	0.6069	-1.9722	0.0373
		F_Achieved_Z	13	-0.7496	0.5325	-1.6454	0.0000
		P_Achieved_Z	13	-0.8474	0.5559	-1.5211	0.2130
		I_Achieved_Z	13	-0.8257	0.5202	-1.9985	0.0000

Note:

C_Achieved_Z = standardized values of Citizen Achieved Results, F_Achieved_Z = standardized values of Citizen Achieved Results

P_Achieved_Z = standardized values of Public Adminstration Achieved Results, I_Achieved_Z = standardized values of Infrastructure Achieved Results

The cluster analysis found clear distinguishable high-, middle-, and low-scorer. It is worth to point out results are consistent within clusters. Countries performing well in one category do also fare well in all other categories and vice versa, as can be seen in Figure 7.

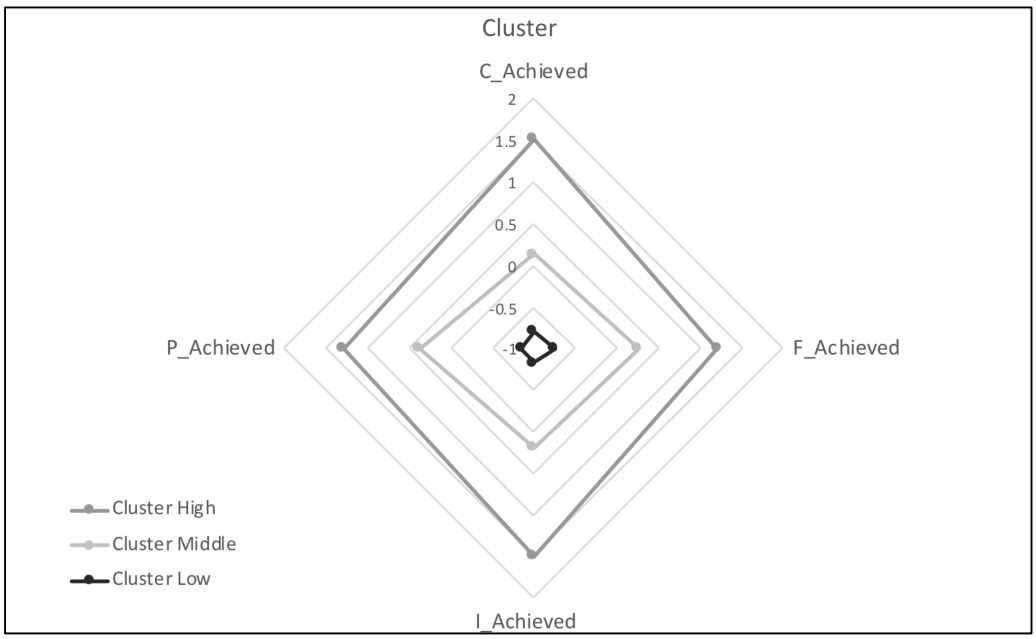


Figure 7: Results - Cluster Analysis 2012

Scheffé (one way analysis of variance) test was used to further examine whether the clusters are reasonable and the differences between clusters are statistically significant (Scheffé, 1953). By comparing the means of each factor and cluster (see Table 29), the Scheffé-adjusted significance value (p-value) is computed.

Table 29: Means of Clusters 2012

	Mean		
	Cluster High	**Cluster Middle**	**Cluster Low**
C_Achieved	1.522	0.132	-0.789
F_Achieved	1.202	0.258	-0.750
P_Achieved	1.293	0.379	-0.847
I_Achieved	1.489	0.183	-0.826

Note:

C_Achieved = Citizen Achieved Results, F_Achieved = Citizen Achieved Results

P_Achieved = Public Adminstration Achieved Results, I_Achieved = Infrastructure Achieved Results

The results of the Scheffé test are presented as a matrix, illustrated in Table 30. The first entry, e.g. 1.390 for C_Achieved, represents the difference between C_Achieved Cluster high (2) and cluster middle (1). Looking at Table 29, it is recognizable that the means of cluster high (2) and cluster middle (1) are 1.522 and 0.132, respectively. Thus 1.522 – 0.132 = 1.390. Underneath that number is reported "0.000". This is the Scheffé-adjusted significance of the difference. Table 30 shows that p-values for all factors and clusters are lower than the threshold of 0.1, suggesting that differences between clusters are significant and clusters are reasonable.

Table 30: Scheffe's Multiple-Comparison test for 2012 Clusters

Row Mean -	C_Achieved		F_Achieved		P_Achieved		I_Achieved	
Col Mean	1	2	1	2	1	2	1	2
2	1.390		0.944		0.914		1.306	
	0.000		0.017		0.008		0.000	
3	-0.921	-2.311	-1.007	-1.952	-1.227	-2.141	-1.009	-2.315
	0.001	0.000	0.002	0.000	0.000	0.000	0.000	0.000

Note: 1= Cluster Middle, 2 = Cluster High, 3= Cluster Low

In a similar fashion, the clusters were compared with the outside variables: GDP, DESI and Doing Business Index. It is worth mentioning that these variables were not included in the clustering step. Table 31 shows the means of the outside variables chosen, and Table 32 provides the results of Scheffé multiple-comparison test.

Table 31: Means of Outside Variables 2012

	Mean		
	Cluster High	Cluster Middle	Cluster Low
GDP per Capita 2012	144.833	105.111	70.846
DESI 2013	57.721	45.682	35.750
Doing Business 2012	79.637	73.116	68.240

Table 32: Scheffe's Multiple-Comparison test for Outside Variables 2012

Row Mean -	GDP		DESI		Doing Business	
Col Mean	1	2	1	2	1	2
2	39.722		12.040		6.520	
	0.065		0.000		0.115	
3	-34.265	-73.987	-9.932	-21.972	-4.876	-11.396
	0.051	0.000	0.000	0.000	0.163	0.002

Note: 1= Cluster Middle, 2 = Cluster High, 3= Cluster Low

The results obtained show that differences between GDP and DMI as well as DESI and DMI are significant. Results of the Doing Business index are somewhat screwed. The comparisons of cluster high (2) with cluster middle (1), and cluster low (3) with cluster middle (1) indicate no significant difference, with a p-value of 0.115 and 0.163 respectively. However, the comparison of cluster low (3) with cluster high (2) shows a statistical difference with a p-value of 0.002. Because of the before identified similarity between the other two clusters, it was decided to disregard this difference and treat all factors as not significantly different.

The findings presented indicate that countries falling under the cluster low in DMI tend also to score low in terms of GDP and DESI. Similar holds true for cluster middle and cluster high. Hence, it can be said that the digital performance of a country measured through the DMI predicts a country's GDP and how it scores in DESI.

4.2.3. Cluster 2016

Having analyzed the 2012 data, a cluster analysis with the 2016 data was performed in the same way as described before, using again three clusters (low, middle and high). However, even though the number of clusters is identical, some countries moved between clusters, marked with either an equal, plus or minus sign after the country (see Table 33).

Table 33: Results Cluster Analysis 2016

2016								
Cluster	**Countries**	**Category**	**Obs.**	***Diff.***	**Mean**	**Std. Dev.**	**Min**	**Max**
Cluster High	**Belgium(+), Germany(+), Luxembourg(=), France(+), United Kingdom(=), Estonia(+), Finland(=), Netherlands(=), Sweden(=), Austria(+), Denmark(=)**	C_Achieved_Z	11	*5*	0.9232	0.6948	0.0000	1.8361
		F_Achieved_Z	11	*5*	0.8295	0.6774	0.0000	1.8014
		I_Achieved_Z	11	*5*	0.9403	0.5818	-0.0933	1.7286
		P_Achieved_Z	11	*5*	0.9313	0.4978	0.2537	1.6993
Cluster Middle	**Poland(+), Malta(=), Czech Republic(+), Slovakia(+), Spain(=), Italy(+), Portugal(+), Cyprus(+), Latvia(+), Croatia(+), Hungary(+), Lituania(+), Slovenia(=)**	C_Achieved_Z	13	*4*	-0.3945	0.3673	-1.2175	0.0477
		F_Achieved_Z	13	*4*	-0.4424	0.4315	-1.0786	0.3064
		I_Achieved_Z	13	*4*	-0.4512	0.4602	-0.9507	0.3709
		P_Achieved_Z	13	*4*	-0.4026	0.5618	-1.2896	0.2782
Cluster Low	**Greece(=), Romanio(=), Bulgaria(=)**	C_Achieved_Z	3	*-10*	-1.6607	0.6597	-2.0664	-0.8994
		F_Achieved_Z	3	*-10*	-1.5343	0.2610	-1.7692	-1.2533
		I_Achieved_Z	3	*-10*	-1.7258	0.4655	-2.2328	-1.3177
		P_Achieved_Z	3	*-10*	-1.6044	0.3928	-2.0505	-1.3101

Note:

C_Achieved_Z = standardized values of Citizen Achieved Results, F_Achieved_Z = standardized values of Fitizen Achieved Results

I_Achieved_Z = standardized values of Infrastructure Achieved Results, P_Achieved_Z = standardized values of Public Adminstration Achieved Results

(+) = moved up one cluster, (-) moved down one cluster, (=) remained same cluster

The cluster analysis found again clear distinguishable high-, middle-, and low-scorer. Also, the 2016 data shows consistency within clusters, strengthening the results of 2012 that a country tends performs equally in all four domains (see Figure 8).

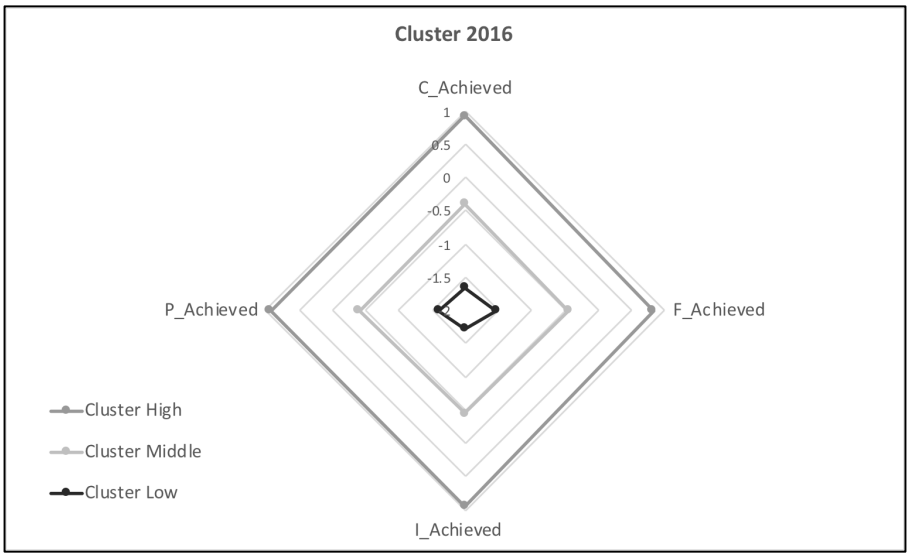


Figure 8: Results - Cluster Analysis 2016

Results of the Scheffé multiple-comparison test for the 2016 clusters can be seen in Table 35, and Table 34 shows the means of each factor.

Table 34: Means of Clusters 2016

	Mean		
	Cluster High	Cluster Middle	Cluster Low
C_Achieved	0.923	-0.395	-1.661
F_Achieved	0.829	-0.442	-1.534
P_Achieved	0.931	-0.403	-1.604
I_Achieved	0.940	-0.451	-1.726

Note:

C_Achieved = Citizen Achieved Results, F_Achieved = Citizen Achieved Results

P_Achieved = Public Adminstration Achieved Results, I_Achieved = Infrastructure Achieved Results

Table 35: Scheffe's Multiple-Comparison test for 2016 Clusters

Row Mean -	C_Achieved		F_Achieved		P_Achieved		I_Achieved	
Col Mean	1	2	1	2	1	2	1	2
2	-2.584		-2.364		-2.536		-2.666	
	0.000		0.000		0.000		0.000	
3	-1.318	1.266	-1.272	1.092	-1.334	1.202	-1.391	1.275
	0.000	0.006	0.000	0.015	0.000	0.006	0.000	0.003

Note: 1= Cluster High, 2 = Cluster Low, 3= Cluster Middle

Like in 2012, the cluster analysis for the 2016 data shows that p-values for all factors and clusters are lower than the threshold of 0.1, confirming that differences between clusters are significant and clusters are reasonable (see Table 35). What jumps out is that differences between clusters in 2016 are larger compared with 2012.

Finally, the 2016 cluster have been compared with the same outside variables (using 2016 values as well).

Table 36 shows the means of the outside variables chosen, and Table 37 provides the results of Scheffé multiple-comparison test.

Table 36: Means of Outside Variables 2012

	Mean		
	Cluster High	Cluster Middle	Cluster Low
GDP per Capita 2016	127.909	78.769	58.000
DESI 2016	61.493	48.405	36.234
Doing Business2016	77.692	68.792	64.180

Table 37: Scheffe's Multiple-Comparison test for Outside Variables 2012

Row Mean -	GDP		DESI		Doing Business	
Col Mean	1	2	1	2	1	2
2	-69.909		-25.259		-13.512	
	0.011		0.000		0.001	
3	-49.140	20.769	-13.087	12.171	-8.900	4.612
	0.005	0.616	0.000	0.006	0.001	0.364

Note: 1= Cluster High, 2 = Cluster Low, 3= Cluster Middle

2016 results are not as clear as previous results. DMI clusters continues to predict a country's DESI score, but lines between DMI, GDP and Doing Business blur, especially between the middle and low cluster.

Comparing DMI clusters with DESI show p-values of 0.000, 0.000 and 0.006, indicating that all clusters are significantly different. In other words, countries that fall under the DMI cluster high tend to score high in DESI as well and vice versa. Results of the other two outside variables differ. The comparison of DMI's middle and low cluster with the GDP shows a p-value of 0.616, hence the difference is no longer significant. Same can be said when comparing DMI with the Doing Business index as cluster middle and cluster low received a p-value of 0.364. The fact that there is no differentiation possible between those two clusters and outside variables is represented in Table 36 with identical color shadings.

4.3. Results Discussion

4.3.1. Verification of the Hypotheses

All except one hypotheses have been confirmed, which provides empirical evidence and confirms the correctness of the newly proposed maturity indices. Moreover, additional (mostly with smaller impact) correlations have been observed, highlighting how intertwined all areas of ICT are and that some dimensions indirectly impact other dimensions. Table 38 lists all checked hypotheses with their corresponding p-value.

One hypothesis was rejected, but this might rather be due to the lack of data instead of an incorrect theoretical framework. That having been said, it would be interesting to run the same analysis with a higher data availability. This might be possible in the near future as the indicators showed better availability at later periods (see 3.6). Following, findings of each domain are discussed, highlighting expected results as well as unexpected results that contradict theory or assumptions made.

Table 38: Hypotheses verified through the Panel data analysis

Hypothesis	Description	Independent Variable	Dependent Variable	P-value
1	*Progress in Citizen Enabling Factors does influence positively the Achieved Results within the Citizen domain*	Citizen Enablers	Citizen Achieved Results	0.007
2	*Progress in Firm Enabling Factors does influence positively the Achieved Results within the Firm domain*	Firm Enablers	Firm Achieved Results	0.007
3	*Progress in Public Administration Enabling Factors does influence positively the Achieved Results within the Public Administration domain*	Public Administration Enablers	Public Administration Achieved Results	0.603
4	*Progress in Infrastructure Enabling Factors does influence positively the Achieved Results within the Infrastructure domain*	Infrastructure Enablers	Infrastructure Achieved Results	0.040
5	*Progress in Public Administration Enabling Factors does influence positively the Achieved Results within the Citizen domain*	Public Administration Enablers	Citizen Achieved Results	0.032
6	*Progress in Public Administration Achieved Results does influence positively the Achieved Results within the Firm domain*	Public Administration Achieved Results	Firm Achieved Results	0.035

Citizen

Citizen's enabling factor has a strong impact on the Achieved results, providing credibility to the first dimension of the DMI.

The fact that improvements within the public administration enablers leads to improvements within the citizen domain highlights the important of government in fostering ICT adoption. In particular, it shows the importance of education and well-equipped schools, which is in many European countries the responsibility of the state and so providing evidence on the importance ICT should have for state leaders. This finding is very well backed by literature, e.g. Kongaut and Bohlin (2015) found correlations with the level of education and ICT usage.

Somewhat surprising is the identified negative correlation of Public Administration Achieved results and the Achieved results of Citizen as it contradicts the findings of West (2004) who argues citizens that interact online with public authorities tend to have a high ICT adoption in general. However, the validity of this finding is in dispute as the sample size was the second lowest with only 25 countries included and due to the fact that the Public Administration Achieved results factor was only composed of three indicators out of 16.

Firm

Enabling factors of the Firm domain have a positive influence on Firm' Achieved results, supporting the assumptions for the second domain of the DMI.

However, even though a strong correlation between enabling factor and achieved results was found, many essential indicators are missing that may represent the ICT adoption of a firm in a more cohesive way. Enabling factor do neither include digital skills nor ICT specialist indicators (e.g. "Science and technology graduates" or "Enterprises employing ICT specialists". Achieved results lack of any e-Business indicators, such as the "Digital Intensity score for Enterprises" or "Enterprises using social media".

Despite the limitation mentioned before, second domain confirms again the important role a government plays in the diffusion of ICT. By supporting hypothesis 6, progress in the Public Administration Achieved results have positive effects on firms, it also confirms assumptions drawn from literature, such as the digitization of bureaucratic procedures leads to productivity gains in firms (OECD, 2014). In addition, this finding partly negates the negative impact identified in the Citizen domain, as Firm's Achieved results includes indicators measuring e-commerce (Business-to-Consumers) activities. It is worth pointing out that this model had a higher sample size than the model used for the Citizen domain and that the Public Administration Achieved results factor included five instead of only three indicators.

Public Administration

No positive effect between Enabling factors and Achieves results were found, hence hypothesis 3 is not supported.

Dataset 2010-2013 got mainly included because it offered more indicators for the Public Administration domain, improving this way the robustness and relevance of the analysis. However, enabling factors and achieved results do not seem to fit together. From a theoretical point of view this is reasonable as all achieved results indicator relate to FP7-ICT projects, that are, EU funded ICT projects. On the other side, indicators included in the enabling factor are "Government effectiveness" and "Individuals interacting online with public authorities, last 12 months", both do not have an apparent connection to EU funded ICT project. In addition, the lack of five countries in the dataset does add further restraints of this result.

Infrastructure

Infrastructure's Enablers impact Achieved result of infrastructure positively, underscoring the theoretical correctness of the DMI.

As discussed in the literature section as well as in the theoretical framework, it can be said that infrastructure is somewhat relevant for all domains (Bertschek et al., 2013, Council, 2002, Drouard, 2010, Mossberger et al., 2012, Sawyer et al., 2003). However, results do not only show how intertwined the domains are, but also how much they depend on each other. For instance, countries having high values in Citizen's achieved results tend to have high results within the Infrastructure domain as well, but this, in turn, is not possible without a good performance in Citizen's enablers as well, since achieved results depend on the latter. Taking this idea one step further it might indicate that if a country aims to improve its level of digital maturity, it needs to focus on all ICT domains. The following analysis sheds light on this thought.

4.3.2. Discussion on the Performance of EU Member States

This chapter discusses the results of the benchmarking performed on all EU members through a clustering method. The aim of this chapter is three-fold: (i) characteristics of low / high performing countries are identified, (ii) factors that led to an advancement / decline in the digital performance of a country are stated, and (iii) common patterns for the development of countries, if existing, are shown.

Firstly, general findings that are cluster independent are highlighted before secondly results of the cluster low are examined, before results of the middle and high clusters are discussed thoroughly.

General Remarks

Three findings are worth pointing out and are valid for all clusters.

DMI clusters are able to predict the position of a country within DESI. Countries performing poor in DMI tend perform poor in DESI, while countries scoring highest in DESI set also the bar for DMI. This finding does not also strengthen the credibility of the DMI, but also gives practitioners a bigger set of tools to analyze their performance in DESI. Since DMI includes significantly more indicators, including areas that DESI does not touch at all, policy makers have a bigger set of options to utilize.

The second finding is related to the homogenous performance of all countries. Irrespective of cluster, almost all countries show an even digital development across all domains. High performer, such as Sweden or Denmark set the bar in all four dimensions, while the lowest values in all four domains, stem from the weakest performing countries, such as Bulgaria. This trend has been observed in other studies as well that measure and compare the digital maturity of countries, for instance Corrocher and Ordanini (2002) found homogenous patterns of digitalization for high performing countries (the USA and UK) or low performing ones (France, Italy and Spain).

Lastly, while there was a lot of movement between clusters, all movements were up, no country moved down a cluster and none of the countries moved either up two clusters during the 4 years period observed.

Cluster Low

The most changes happened within the low scoring clusters. In total 10 countries moved upwards, suggesting not all countries could close the gap to the countries in the middle performing cluster. The three countries remaining are Bulgaria, Greece and Romania, which are the countries that represent the bottom of the DESI, confirming the results above. Table 39 takes a closer look into the results and compares results of each category between 2012 and 2016. It can be said that Bulgaria and Romania do not only stagnate, but the gap between those two countries and the better performing ones has widened. As the difference between the 2012 and 2016 values in all categories are negative, the distance to the mean has increased and so has the distance to the middle cluster. As the standardization was performed separately on 2012 and 2016 datasets, a negative difference does not necessarily imply that the country has not improved at all nor that the performance has declined, but it means that in comparison with all other countries the distance has increased. For example, consider Bulgaria's value of 2012 and 2016 for the Citizen Achieved domain, -1.5348 and -2.0162 respectively. One could assume

that Bulgaria's performance was declining as the 2016 value is lower compared to 2012. But this is not necessarily the case as both values are standardized. The actual value of 2016 might be higher than in 2012, but compared with other countries the distance to the mean of all countries has increased, because remaining countries improved faster than Bulgaria. This trend is striking and supports studies that envisage a digital divide in the EU (Corrocher and Ordanini, 2002, Moroz, 2017).

That having been said, both Bulgaria and Romania show weak performances in all domains within the achieved results category. Taking into account the scores in the enabling categories, it can be said Bulgaria lost ground in the Citizen and Firm domain, while Romania fared extremely bad within Infrastructure. However, due to lack of a corresponding value in 2012, it is not clear whether Romania did improve in this domain. The next best candidate to move up and close the gap to better performing countries is Greece. Having improved the citizen's achieved results and keeping Infrastructure leveled, further advancements can be expected within the next years. However, the decline in the Public Administration domain, in both domains (achieved results and enabling factor) is alarming and should be mitigated to not hinder further improvements.

Table 39: Cluster Low - Performance comparison

Cluster Low									
Countries	**Position**	**Category**	**2012**	**2016**	***Difference***	**Category**	**2012**	**2016**	***Difference***
Bulgaria	(=)	C_Achieved	-1.5348	-2.0162	*-0.4814*	C_Enablers	-1.4304	-1.7619	*-0.3315*
	(=)	F_Achieved	-1.4714	-1.5804	*-0.1090*	F_Enablers	-1.5144	-2.0294	*-0.5149*
	(=)	P_Achieved	-1.4317	-1.4526	*-0.0210*	P_Enablers	-0.8586	-0.6603	*0.1983*
	(=)	I_Achieved	-1.9985	-2.2328	*-0.2343*	I_Enablers	-1.0063	-1.0657	*-0.0594*
Greece	(=)	C_Achieved	-1.2653	-0.8994	*0.3659*	C_Enablers	-1.3119	-1.3764	*-0.0645*
	(=)	F_Achieved	0.0000	-1.2533	*n/a*	F_Enablers	-1.0928	-1.3870	*-0.2942*
	(=)	P_Achieved	-1.0821	-1.3101	*-0.2280*	P_Enablers	-1.3847	-1.7917	*-0.4070*
	(=)	I_Achieved	-1.3497	-1.3177	*0.0320*	I_Enablers	-0.1879	-1.1701	*-0.9822*
Romania	(=)	C_Achieved	-1.9722	-2.0664	*-0.0942*	C_Enablers	-1.3777	-1.2304	*0.1473*
	(=)	F_Achieved	-1.6454	-1.7692	*-0.1238*	F_Enablers	-1.8786	-2.0199	*-0.1414*
	(=)	P_Achieved	-1.5211	-2.0505	*-0.5294*	P_Enablers	-1.4388	-1.0224	*0.4164*
	(=)	I_Achieved	0.0000	-1.6268	*n/a*	I_Enablers	-0.5759	-2.5454	*-1.9695*

Note: *C_*= Citizen, F_* = Firm, P_* = Public Administration, I_* = Infrastructure*

Cluster Middle

In 2016, this cluster included four countries more than in 2012, and in total ten new countries entered. All of them moved upwards, no country has moved down. Having been better performers in their old cluster, those countries are now presumably the lower performers of the middle cluster. The following table shows the new entering country and indicates in which areas they improved to make this jump possible.

Table 40 reveals several remarkable insights. Czech Republic is the country that made the largest progress. Drivers of that progression are strong improvements in the Citizen, Firm and Infrastructure domain, while performing slightly worse within Public Administration. This growth is fueled by large improvements in the Citizen and Infrastructure enabling factors.

A good case for the importance of Public Administration is Latvia. Even though declining values in Citizen and Infrastructure Achieved results, it has closed the gap to the middle cluster with huge advancements in the Public Administration domain and some progression in Firm's achieved result. As all enabling factors except Citizen has improved as well, it can be expected that Latvia further improves in the future. The strong result in the Infrastructure enablers might indicate that Latvia has already realized its weak point and took successfully measures against it.

Portugal is another country worth to point out. With constant improvements in three out of four achieved results it made substantial progress compared to 2012. However, with a high negative difference in the enabling factor dimension, Portugal might has reached a turning point and is not able to continue this trend.

The opposite holds for Italy, which improved only slightly in the achieved results but has scored high in the Infrastructure enabling factors, suggesting strong improvements in the future.

Table 40: Cluster Middle - Performance comparison of up-movers

Cluster Middle									
Countries	Position	Category	2012	2016	*Difference*	Category	2012	2016	*Difference*
Croatia	(+)	C_Achieved	-0.4883	-0.5327	*-0.0444*	C_Enablers	-0.7153	-0.8111	*-0.0958*
	(+)	F_Achieved	0.0000	-0.3918	*n/a*	F_Enablers	0.5313	0.4198	*-0.1114*
	(+)	P_Achieved	-1.0886	-0.9701	*0.1185*	P_Enablers	-1.0962	-1.0454	*0.0508*
	(+)	I_Achieved	-0.7098	-0.8418	*-0.1321*	I_Enablers	-0.9632	-1.3378	*-0.3746*
Cyprus	(+)	C_Achieved	-0.7687	-0.4171	*0.3516*	C_Enablers	-0.5178	-0.6849	*-0.1671*
	(+)	F_Achieved	-1.0592	-1.0786	*-0.0194*	F_Enablers	-0.5921	-0.7076	*-0.1155*
	(+)	P_Achieved	0.0000	0.0000	*n/a*	P_Enablers	-0.0384	-0.8676	*-0.8292*
	(+)	I_Achieved	-0.5553	-0.3074	*0.2479*	I_Enablers	-0.1570	-0.2090	*-0.0520*
Czech Republic	(+)	C_Achieved	-0.6439	0.0477	*0.6916*	C_Enablers	-0.5569	0.1758	*0.7328*
	(+)	F_Achieved	-0.4759	-0.0653	*0.4105*	F_Enablers	0.8018	0.5183	*-0.2835*
	(+)	P_Achieved	-0.8931	-0.9741	*-0.0811*	P_Enablers	-0.6732	-0.8288	*-0.1556*
	(+)	I_Achieved	-0.6959	-0.1531	*0.5428*	I_Enablers	-0.4998	0.4241	*0.9239*
Hungary	(+)	C_Achieved	-0.1390	-0.0229	*0.1161*	C_Enablers	-0.6965	-0.5056	*0.1909*
	(+)	F_Achieved	-0.5349	-0.5581	*-0.0232*	F_Enablers	-0.8769	-0.7796	*0.0972*
	(+)	P_Achieved	-0.7205	-0.9950	*-0.2745*	P_Enablers	-0.6015	-0.8022	*-0.2007*
	(+)	I_Achieved	-1.1228	-0.7120	*0.4108*	I_Enablers	-0.0110	0.1377	*0.1488*
Italy	(+)	C_Achieved	-1.2520	-1.2175	*0.0346*	C_Enablers	-0.8869	-0.7329	*0.1540*
	(+)	F_Achieved	-1.1384	-1.0362	*0.1022*	F_Enablers	-0.8769	-0.9923	*-0.1154*
	(+)	P_Achieved	-1.1543	0.0000	*n/a*	P_Enablers	-1.0022	-1.1762	*-0.1740*
	(+)	I_Achieved	-0.9027	-0.6704	*0.2323*	I_Enablers	-1.0195	0.0118	*1.0313*
Latvia	(+)	C_Achieved	0.0373	-0.2236	*-0.2609*	C_Enablers	-0.5990	-0.7334	*-0.1344*
	(+)	F_Achieved	-0.8836	-0.4860	*0.3977*	F_Enablers	-1.0982	-0.8994	*0.1988*
	(+)	P_Achieved	-0.8154	-0.1134	*0.7020*	P_Enablers	-0.8590	-0.5301	*0.3289*
	(+)	I_Achieved	-0.6285	-0.9507	*-0.3222*	I_Enablers	-0.4901	0.1801	*0.6702*
Lituania	(+)	C_Achieved	-0.4715	-0.4499	*0.0216*	C_Enablers	-0.9618	-1.1863	*-0.2245*
	(+)	F_Achieved	-0.9812	-0.8437	*0.1375*	F_Enablers	-0.4843	-0.3387	*0.1455*
	(+)	P_Achieved	-0.0956	0.2782	*0.3738*	P_Enablers	-0.1657	0.2177	*0.3834*
	(+)	I_Achieved	-0.7247	-0.8281	*-0.1034*	I_Enablers	0.2653	0.0000	*n/a*
Poland	(+)	C_Achieved	-0.9513	-0.9053	*0.0460*	C_Enablers	-0.5001	-0.3100	*0.1901*
	(+)	F_Achieved	-0.6837	-0.5303	*0.1533*	F_Enablers	-0.8993	-0.6600	*0.2393*
	(+)	P_Achieved	-1.2865	-1.2896	*-0.0031*	P_Enablers	-1.3241	-1.1889	*0.1352*
	(+)	I_Achieved	-0.6318	-0.7986	*-0.1668*	I_Enablers	-1.2716	-1.3208	*-0.0493*
Portugal	(+)	C_Achieved	-0.8441	-0.6224	*0.2217*	C_Enablers	-0.9464	-0.9718	*-0.0253*
	(+)	F_Achieved	-0.8316	-0.7200	*0.1116*	F_Enablers	-0.8101	-0.3341	*0.4761*
	(+)	P_Achieved	0.2130	0.1913	*-0.0217*	P_Enablers	1.0766	0.7083	*-0.3683*
	(+)	I_Achieved	-1.2565	-0.8805	*0.3760*	I_Enablers	2.1556	1.1605	*-0.9951*
Slovakia	(+)	C_Achieved	0.0324	-0.2070	*-0.2394*	C_Enablers	-0.3471	-0.5907	*-0.2435*
	(+)	F_Achieved	-0.0391	0.2118	*0.2509*	F_Enablers	-0.0005	-0.2541	*-0.2535*
	(+)	P_Achieved	-1.1409	-0.9830	*0.1580*	P_Enablers	-0.9523	-0.7131	*0.2392*
	(+)	I_Achieved	-0.1580	-0.4446	*-0.2866*	I_Enablers	-2.0282	-1.1947	*0.8335*

Note: *C_*= Citizen, F_* = Firm, P_* = Public Administration, I_* = Infrastructure*

The following table shows the three countries that have not moved, but stayed in the cluster middle. While Malta and Slovenia show a downward trend, Spain represents the next candidate to move up a cluster as it was able to improve over averagely in three out of four dimensions.

Table 41: Cluster Middle - Performance comparison of countries that remained in same cluster

Cluster Middle									
Countries	**Position**	**Category**	**2012**	**2016**	***Difference***	**Category**	**2012**	**2016**	***Difference***
Malta	(=)	C_Achieved	-0.3140	-0.0659	*0.2481*	C_Enablers	0.7265	0.5890	*-0.1374*
	(=)	F_Achieved	0.1991	0.3064	*0.1073*	F_Enablers	-0.3592	0.0421	*0.4013*
	(=)	P_Achieved	0.3050	-0.1934	*-0.4983*	P_Enablers	1.4385	0.4934	*-0.9450*
	(=)	I_Achieved	0.4216	0.2304	*-0.1913*	I_Enablers	0.3866	0.7742	*0.3877*
Slovenia	(=)	C_Achieved	-0.3780	-0.4318	*-0.0538*	C_Enablers	-0.1691	-0.4304	*-0.2613*
	(=)	F_Achieved	0.0344	-0.4010	*-0.4354*	F_Enablers	0.1744	0.3492	*0.1748*
	(=)	P_Achieved	-0.1565	-0.4117	*-0.2552*	P_Enablers	-1.4128	-1.3691	*0.0437*
	(=)	I_Achieved	-0.0849	0.1205	*0.2054*	I_Enablers	-0.7760	0.4534	*1.2294*
Spain	(=)	C_Achieved	-0.1805	-0.0805	*0.1001*	C_Enablers	-0.6744	-0.4626	*0.2118*
	(=)	F_Achieved	-0.5032	-0.1582	*0.3450*	F_Enablers	-0.1859	0.1901	*0.3759*
	(=)	P_Achieved	0.3079	0.2269	*-0.0811*	P_Enablers	-0.4410	-0.3380	*0.1030*
	(=)	I_Achieved	-0.0553	0.3709	*0.4262*	I_Enablers	-0.3074	-0.0672	*0.2403*

Note: *C_*= Citizen, F_* = Firm, P_* = Public Administration, I_* = Infrastructure*

Cluster High

Five countries joined the leading pack, increasing the number of observations from six to eleven. What jumps out is the fact that France has a negative difference, suggesting the distance to leading countries have increased. Nonetheless, it moved up implying despite that negative trend. It can be assumed that in 2012 France was already close to the cluster high. Since the number of countries in the cluster was smaller, there were too many high performers in the cluster, pushing France into the cluster middle. With all the countries moving up, the threshold to enter into the cluster high has fallen so that France now belongs to it, even though it performed worse in comparison with other country in the cluster. More evidence is provided by the addition of Austria and Belgium, who entered the high cluster with minor improvements compared to 2012. Estonia, France and Germany have a large negative difference in the Infrastructure domain.

Table 42: Cluster High - Performance comparison of up-movers

Cluster High									
Countries	**Position**	**Category**	**2012**	**2016**	***Difference***	**Category**	**2012**	**2016**	***Difference***
Austria	(+)	C_Achieved	0.2852	0.1425	*-0.1427*	C_Enablers	0.4820	0.5072	*0.0253*
Austria	(+)	F_Achieved	0.4991	0.6984	*0.1993*	F_Enablers	0.4145	0.4031	*-0.0114*
Austria	(+)	P_Achieved	0.6481	0.4946	*-0.1535*	P_Enablers	0.6225	0.5810	*-0.0415*
Austria	(+)	I_Achieved	0.4127	0.4021	*-0.0106*	I_Enablers	0.2934	0.0000	*n/a*
Belgium	(+)	C_Achieved	0.4656	0.3964	*-0.0691*	C_Enablers	0.0764	0.1346	*0.0582*
Belgium	(+)	F_Achieved	0.2121	0.8207	*0.6086*	F_Enablers	0.4708	0.7252	*0.2544*
Belgium	(+)	P_Achieved	0.3880	0.2537	*-0.1343*	P_Enablers	0.0203	0.0672	*0.0469*
Belgium	(+)	I_Achieved	0.1746	0.2699	*0.0954*	I_Enablers	0.5312	1.2821	*0.7509*
Estonia	(+)	C_Achieved	0.5393	0.7716	*0.2324*	C_Enablers	-0.0929	0.2856	*0.3785*
Estonia	(+)	F_Achieved	-0.6531	0.5197	*1.1729*	F_Enablers	-0.4235	-0.0016	*0.4219*
Estonia	(+)	P_Achieved	0.8947	1.2555	*0.3608*	P_Enablers	1.3154	1.6519	*0.3366*
Estonia	(+)	I_Achieved	-0.1863	0.7396	*0.9259*	I_Enablers	0.4309	-0.2493	*-0.6802*
France	(+)	C_Achieved	0.3330	0.2059	*-0.1271*	C_Enablers	-0.0203	0.0826	*0.1029*
France	(+)	F_Achieved	0.7793	0.7557	*-0.0236*	F_Enablers	-0.2544	-0.1887	*0.0657*
France	(+)	P_Achieved	0.7704	0.4900	*-0.2804*	P_Enablers	0.5352	0.5823	*0.0471*
France	(+)	I_Achieved	0.6582	-0.0933	*-0.7514*	I_Enablers	-1.0480	-1.4154	*-0.3674*
Germany	(+)	C_Achieved	0.4235	0.6381	*0.2146*	C_Enablers	0.7245	1.0279	*0.3034*
Germany	(+)	F_Achieved	1.2253	1.3420	*0.1167*	F_Enablers	0.1162	0.2025	*0.0863*
Germany	(+)	P_Achieved	0.3331	0.3567	*0.0236*	P_Enablers	0.2965	0.6079	*0.3115*
Germany	(+)	I_Achieved	0.5003	0.7233	*0.2229*	I_Enablers	0.8008	0.2583	*-0.5426*

The remaining part of the results show negative differences for the leading countries, e.g. Sweden or Finland. This is somewhat plausible, as those countries represent the upper boundary of the indicators and improvements are much harder and costly (sometimes even not possible) than for following countries, while it is easier and less costly for lower performing countries to improve. This creates a ripple effect which increases the total average of the EU as many mediocre and / or low performing countries improve.

The same trend is reflected in the enabling factor results, which are declining. With high values in all categories, it is likely that those countries will remain the leading countries in the near future.

Table 43: Cluster High - Performance comparison of countries that remained in same cluster

Cluster High									
Countries	**Position**	**Category**	**2012**	**2016**	***Difference***	**Category**	**2012**	**2016**	***Difference***
Denmark	(=)	C_Achieved	1.6044	1.8000	*0.1956*	C_Enablers	1.8047	1.1817	*-0.6230*
Denmark	(=)	F_Achieved	0.0000	0.0000	*n/a*	F_Enablers	1.7990	2.0859	*0.2869*
Denmark	(=)	P_Achieved	1.9564	1.6993	*-0.2571*	P_Enablers	1.2663	0.6689	*-0.5974*
Denmark	(=)	I_Achieved	1.5686	1.4954	*-0.0732*	I_Enablers	1.3741	1.2326	*-0.1416*
Finland	(=)	C_Achieved	1.6778	1.5581	*-0.1197*	C_Enablers	1.1458	1.1204	*-0.0255*
Finland	(=)	F_Achieved	1.3076	0.0000	*n/a*	F_Enablers	2.1651	1.8698	*-0.2953*
Finland	(=)	P_Achieved	1.5798	1.4701	*-0.1097*	P_Enablers	1.1944	1.0056	*-0.1888*
Finland	(=)	I_Achieved	1.4396	1.2225	*-0.2171*	I_Enablers	1.0123	0.2711	*-0.7412*
Luxembourg	(=)	C_Achieved	1.4962	1.8361	*0.3399*	C_Enablers	1.6836	2.0286	*0.3450*
Luxembourg	(=)	F_Achieved	1.8445	0.0000	*n/a*	F_Enablers	0.5405	0.1846	*-0.3559*
Luxembourg	(=)	P_Achieved	0.7209	0.7709	*0.0500*	P_Enablers	1.3890	2.2120	*0.8230*
Luxembourg	(=)	I_Achieved	0.9518	1.7286	*0.7768*	I_Enablers	1.8579	1.1706	*-0.6872*
Netherlands	(=)	C_Achieved	1.5150	1.4453	*-0.0698*	C_Enablers	2.3024	2.1973	*-0.1052*
Netherlands	(=)	F_Achieved	0.9591	1.7208	*0.7616*	F_Enablers	0.4683	0.5645	*0.0962*
Netherlands	(=)	P_Achieved	1.1345	1.2789	*0.1444*	P_Enablers	0.6738	0.7739	*0.1001*
Netherlands	(=)	I_Achieved	1.5448	1.5553	*0.0105*	I_Enablers	0.3567	1.1235	*0.7668*
Sweden	(=)	C_Achieved	1.8510	0.0000	*n/a*	C_Enablers	1.2790	1.2290	*-0.0501*
Sweden	(=)	F_Achieved	1.5237	1.4653	*-0.0584*	F_Enablers	2.0096	1.8243	*-0.1853*
Sweden	(=)	P_Achieved	1.7772	1.3354	*-0.4418*	P_Enablers	1.6651	0.8558	*-0.8093*
Sweden	(=)	I_Achieved	1.7862	1.0628	*-0.7234*	I_Enablers	1.7578	0.7345	*-1.0233*
United Kingdom	(=)	C_Achieved	0.9875	1.3610	*0.3735*	C_Enablers	1.0396	0.9432	*-0.0964*
United Kingdom	(=)	F_Achieved	1.5791	1.8014	*0.2222*	F_Enablers	0.7046	0.1655	*-0.5391*
United Kingdom	(=)	P_Achieved	0.5906	0.8388	*0.2482*	P_Enablers	0.8386	1.2755	*0.4368*
United Kingdom	(=)	I_Achieved	1.6451	1.2370	*-0.4081*	I_Enablers	0.2076	0.9893	*0.7817*

Note: *C_*= Citizen, F_* = Firm, P_* = Public Administration, I_* = Infrastructure*

5. Conclusion

The objective of the thesis was to measure the digital performance of the EU member states in a comprehensive and thorough way, extracting valuable insights from the measured performance to guideline the digital development of countries. Two research questions were developed: RQ1 and RQ2.

RQ1: How can the digital maturity of a country be measured in order to provide policy makers with profound, comprehensive insights for increasing it?

Consequently, a new index was constructed, guided by the insights drawn from literature which were stated as 6 hypotheses. The new index consists of 179 indicators, respecting the various areas ICT has an impact on. Within the four dimensions of the DMI (Citizen, Firm, Public Administration and Infrastructure), two sub-categories are installed named Enabling factors and Achieved results. It is assumed that improvements in enabling factors lead to improvements in Achieved results. The underlying assumptions of the index were examined through a longitudinal analysis (also called panel data analysis), investigating whether the correlations stated in the hypothesis are true. The analysis found that five out if six hypotheses are supported through empirical evidence, giving the DMI credibility and robustness. The reason for the rejection of one hypothesis is presumably due to the low data availability that shrunk number of indicators as low as 38 indicators for one dataset used and not due to incorrect model specifications.

The newly created index represents a powerful tool to measure the digital maturity of a country and allows policy makers and state leaders to gain profound insights on their countries performance. The correlation stated between Enabling factors and Achieved results provides rich guidance on how to improve certain areas of ICT. Through the comprehensiveness of this index, decision makers are enabled to not only make better, but also more informed decisions.

RQ2: What are features of a digital high / low performer? Countries that improved / worsen their digital performance, which were the relevant factors for the advancement / decline? Are there common patterns so that several countries pursue a similar digital development?

In order to answer the second research question, the DMI was used and a cluster analysis performed to group countries according to their performance. Three clusters were identified, representing low-, middle- and high performing countries.

The main feature identified for both low and high performer was a homogenous performance in all dimensions. Irrespective of the cluster, a country was either scoring low, high or mediocre

in all four dimensions. Some small outliers were found, but the overall trend was clear. Furthermore, high performer tended to show little improvement throughout the four years, some were even declining, highlighting the fact that once a country set the bar it is harder or costlier to improve even further. On the other side, it is easier or cheaper for following countries to close the gap to leading countries, which explains the large upward movement of cluster low countries to the middle cluster and cluster middle countries to the high cluster. That said, low performing countries did perform low in all four dimensions and countries from the middle cluster tend to perform mediocre in all dimensions, conforming the homogenous behavior mentioned before.

Due to the observed homogeneity, there is not one relevant factor that is more important over others. However, it was observed that if countries performed in one (or more) dimension worse compared to the remaining dimensions, they showed larger improvements in that weak performing area, leveling the overall performance this way. For countries that showed a declining performance, a different observation was made. When a country's overall performance is declining, often there is one dimension declining significantly more than the other. This holds true especially for low performing countries.

Thus, the observed common pattern is the homogeneous digital performance of most of the countries and a sort of leveling effect for countries that showed uneven results in one of the dimensions.

This finding suggests a more holistic approach is necessary for state leaders and other decision maker, when the objective is to improve the digital performance of their country. What can be taken out by the results as a general remark, is a slowly increasing divide between few low performer and the rest. The bottom of countries seems to be unable to catch up while the leading pack increase their edge.

5.1. Academic & Managerial implications

Academic contribution

Researchers from several areas can gain valuable insights from this thesis as it interacts with a number of other related areas, such as social science, political science, business. The common denominator is ICT, which is why the contribution of this thesis is also relevant for researchers from the Information Technology discipline.

A new index was created based on the findings drawn from literature. Hence, the index is based on established knowledge but the interdisciplinary and comprehensive approach represents a next step in measuring the digital performance of a country. The fact that this index includes

so many different perspectives is the first valuable contribution for academia. To the author's knowledge, no other benchmark study nor index provides such a broad spectrum of relevant and divers factors. Previous studies focused either on one actor (e.g. individuals or firms), or measured only specific outcomes, such as increase in productivity or in GDP.

It further represents the answer to the call for a new statistical tool to measure the digital economy, requested by the OECD (2014). The authors argue that current statistic measures are able to estimate ICT diffusion, but lack of the capability to keep up with the new and rapidly evolving technologies as well as how firms and citizen deploy them. DMI with its scores of diverse indicators is able to fill this gap.

Lastly, this thesis confirmed numerous existing viewpoints in academia, connoting that ICT has the power to:

a) improve a nation's economy in terms of productivity gains (Jalava and Pohjola, 2002, Oliner and Sichel, 2000, Oulton, 2001),
b) improve a person's well-being (Ganju et al., 2015, Helliwell and Putnam, 2004, Wang and Wellman, 2010), and
c) enable firms to boost their performance (Bertschek et al., 2013, Bloom et al., 2014, Bresnahan et al., 2002).

Managerial

This thesis provides a plethora of information for practitioners and can facilitate the decision making for policy makers.

On a general note, it has been argued extensively how crucial the role of public administrations is in fostering the ICT diffusion in their country. The presented and discussed findings may motivate policy makers to bump up digitization for public services. As it has been demonstrated that policy makers influence the ICT adoption directly as well as indirectly. Subsidies such as tax cuts, or funds related to ICT have a profound and direct impact on a country's ICT diffusion, spurring on higher ICT investments in firms leading to more innovation which in turn increases productivity or sales, enabling firms to enlarge their workforce.

A number of indirect measures exist for policy makers. Nurture digital skills in education will eventually result in citizens that are more technical inclined, boosting the demand for ICT applications. Laws can increase trust in ICT and lower the reluctance of some citizens or firms to adopt ICT. Furthermore, a government with a clear and transparent digital strategy acts as a role model and motivates its citizens, stepwise, to adopt. The more digital a government is and

the more administrative procedures are digitized, the more its citizen and firms will be encouraged to switch und use them.

The DMI has further contributions to practitioners. It gives them an additional tool to support their decision making for their digital agendas. One of the de-facto standards in the EU is DESI which is provided and updated by the European Commission. As they have their own digital agenda, DESI does not necessarily focus on the same areas that are particularly relevant for state leaders. DMI provides more flexibility and includes more dimensions than DESI, hence giving a much more detailed picture of a country's performance. The fact that in both periods the DMI clusters are comparable with the DESI ranking gives the DMI even more credibility. In addition to DESI, DMI offers many more levers to improve a country's performance for a certain category. It further provides information about interdependencies between categories, allowing policy makers to know exactly in what areas to invest to improve in a specific category.

Some other tools, e.g. stepwise benchmarking from Petrović et al. (2014) propose development paths for countries in which they copy more successful countries that show similar characteristics. If country makers opt to follow this "best practice" approach, DMI can provide additional useful insights and decipher what measures that country applied and how effective they were.

Finally, by clustering countries according their performance and comparing two time periods, it has been possible to show successful strategies to improve a country's digital maturity. As the findings show, successful countries have a homogenous performance and up-moving countries, that are countries with a leap in their performance, tend to improve more in their weakest dimensions (if they had an unbalanced performance before) compared to the dimensions they are already strong.

5.2. Limitations and Outlook for Future Research

Limitations

The main limitation of this thesis has been addressed in chapter 3.6, that is the data availability. Having provided a framework with 179 indicators the actual number if indicators used is much lower and ranges from 38 – 59, leaving a lot of potential on the table. It is also presumed that the one rejected hypothesis is due to the low data availability. There are a lot of changes in the world of ICT within 10 years, which is why this thesis opted to use as recent data as possible. Hence, a cut-off has been made for data that was discontinued before 2014 and all indicators that had no data for 2014 or later years were dropped. The final indicators included showed

different levels of data availability. Only few had data for all years included in the index (2010-2016), some collect their data only every two years and a large number of indicators started their collection 2014 or later. For the analysis carried out, historical data was required. And it was desired to put at least three years between the two periods measured, as some measures take time before effects can be measured. Due to the decisions made and the cut-off, the data availability for the years 2010-2013 was much lower than for succeeding years, resulting in low availability for the analysis performed. The higher data availability in 2014 and following years, provides good reasons to presume a much higher data availability in the future.

On a theoretical level, the thesis provided a somewhat biased judgement about ICT and provided only argues in favor of a higher ICT adoption. As it was mentioned in the beginning, it was out of scope to provide counter arguments on ICT diffusion and discuss them, since the objective of the thesis was to measure the digital performance. Nonetheless, it is worth pointing out, studies exist that questions ICT role in boosting the productivity of a nation or the well-being of citizens. Furthermore, many scholars mention the divide ICT creates and highlighting when winners emerge, some other players will lose. Often, when scholars talk about a digital divide they compare developed with developing countries, e.g. G7 countries with emerging countries from Asia or Africa. However, a divide is similar observable in the EU which was only briefly mentioned in this thesis.

The final shortcoming is related to the connection of a countries digital maturity and used appropriations. It limits the findings in two ways: first it is unclear which policy, initiative or law has led to the observed advancement / decline in a country's digital performance and secondly, it cannot be ascertained how efficient the measures were as no pecuniary information are included. The first point is relevant as it would provide further information on the relation between installed measures and enabling factors of DMI. For instance, DMI shows that schools that provide internet access or ICT education in general, result in citizens that are more technical inclined and interested in ICT adoption. However, the actual policy, measure or initiative that enabled schools to provide internet or ICT education is not explained. The second point is similar important, knowing that a country's budget has to be balanced and it has to be used in a sustainable and profitable manner, increasing the wealth of its citizens. Hence, knowing the price tag of the initiatives enables policy makers to compare cost with its benefits and supports them in their decision making.

Future Research

Considering the limitations identified, opportunities for further research exist, stemming from this thesis and its findings. Most certainly, it would be highly interesting to conduct a similar

analysis with the same framework one to two years down the road. Not only would the data availability increase due to the additional indicators that started collecting data after 2014, but also the longitudinal analysis could consider a longer time period. With higher data availability, it would be particularly interesting to observe whether the hypotheses are still supported and whether a correlation for the rejected hypothesis can be observed or not. Furthermore, raising the number of indicators makes the DMI even more comprehensive as it already is and reinforces its main advantage.

Researchers have ample options to further contribute to this thesis. As already stressed before, the thesis remained shy of elaborating the digital divide observed in the EU. Considering the fact that the three countries of the lowest cluster border each other and do represent the south-east border of the EU, it would be valuable to probe if outside factors, such as geographical distance, cultural heritage, etc. affect the digital development negatively.

The missing link between governmental actions and achieved results described before, could be established by connecting the performance of each country with the corresponding digital agenda. It would be a unique and value-adding contribution, showing the full lifecycle of enacted policies, laws or initiatives and the impact they created. This contribution could be enhanced even further, by providing pecuniary information. In a consecutive step, a total new set of indicators could then be introduced quantifying the effect of policies and laws. That having been said, additional indicators can be added as well, taking into account the dynamic nature of ICT and the speed of developments in this area.

Besides tackling the limitations of the thesis, emerging ICT areas that this thesis let unexplored can be investigated, such as e-justice on a governmental level, e-supply chain for firms, or digital citizenships considering citizens. In addition, the thesis did fall short to delve into the smart movement and how it impacts society, e.g. smart cities, smart working or smart home to name just a few.

Lastly, DMI currently focusses only on the EU and it member states. Applying the same framework on a global level could set new benchmarks for the top performing countries in the EU. Especially interesting would it be to observe differences between developed and developing countries or the digital development of countries with stark differences to the EU member states, for instance mega states as India, or the capitalistic / communistic led China.

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Annex I: Full KPI list

Category (to be)	Sub-category (enablers/achieved results)	Category (as is)	Indicator	Definition	Org. ID	Unit of measure
Citizens	Enablers	Internet usage	Households with access to the Internet at home	Any member of the household has access to the Internet at home	h_iacc	pc_hh
Citizens	Enablers	Digital Skills	Individuals who have obtained ICT skills through formal educational institutions	Individuals who have obtained ICT skills through formal educational institutions (school, college, university, etc.)	i_skedu	pc_ind
Citizens	Enablers	Digital Skills	Households with computer	Percentage of households with PC	digskill_hh_pc	%
Citizens	Enablers	Security and Privacy	Secure Internet servers	Secure Internet servers are servers using encryption technology in Internet transactions.	sec_internet_ servers	% (was number of secure internet servers per million people)
Citizens	Achieved results	Internet usage	Individuals who have used internet in the last 3 months		i_iu3	pc_ind
Citizens	Achieved results	Internet usage	Individuals who have used internet in the last 12 months		i_ilt12	pc_ind
Citizens	Achieved results	Internet usage	Individuals who are regular internet users (at least once a week)	Individuals using the internet at least once a week in the last 3 months.	i_iuse	pc_ind
Citizens	Achieved results	Internet usage	Individuals who are frequent internet users (every day or almost every day)	Individuals using the internet every day or almost every day, in the last 3 months.	i_iday	pc_ind
Citizens	Achieved results	Internet usage	Individuals using a laptop/tablet to access the internet, away from home or work	Individuals using a portable computer (laptop) to access the internet away from home or work via any wireless connection (WiFi or cellular networks), in the last 3 months. Since 2012 the question explicitly mention also tablet computer (with touch screen).	i_iumc	pc_ind
Citizens	Achieved results	Internet usage	Individuals who have never used the internet		i_iux	pc_ind
Citizens	Achieved results	Internet usage	Diversification index for the activities realised online by internet users	The diversification index is based on counting how many activities, out of a list of 12, have been realised at least once in the previous months. It is computed at individual level for those individuals having used internet in the last 3 months.	i_ia12ave	ia12ave
Citizens	Achieved results	Audiovisual & media content	Reading / downloading online newspapers / news magazines	Individuals have used Internet, in the last 3 months, for reading / downloading online newspapers / news magazines	i_iunw	pc_ind
Citizens	Achieved results	Audiovisual & media content	Playing or downloading games, images, films or music	Individuals have used Internet, in the last 3 months, for playing or downloading games, images films or music	i_iugm	pc_ind
Citizens	Achieved results	Audiovisual & media content	Households subscribed to Video on Demand	Percentage of households subscribing to any form of Video on Demand; EU average calculated as the average of the 26 MS (for which data is available) weighted by the number of households in each of them in 2013	vod	pc_Ebhh_tv
Citizens	Achieved results	Audiovisual & media content	Individuals watching video on demand from commercial services	Individuals watching video on demand from commercial services	i_iuvod	pc_ind
Citizens	Achieved results	Take up of internet services	Looking for information about goods and services online	Individuals have used Internet, in the last 3 months, for finding information about goods and services	i_iuif	pc_ind
Citizens	Achieved results	Take up of internet services	Using online banking	Individuals have used Internet, in the last 3 months, for Internet banking	i_iubk	pc_ind
Citizens	Achieved results	Take up of internet services	Telephoning or video calls (via webcam) over the internet		I_IUPH1	pc_ind
Citizens	Achieved results	Take up of	Uploading self-created content	Individuals have used Internet, in the last 3 months, for uploading self-created content	i_iuupl	pc_ind

		internet services	to be shared	(text, images, photos, videos, music, etc.)		
Citizens	Achieved results	Take up of internet services	Participating in social networks, over the internet, last 3 months	Individuals have used Internet, in the last 3 months, for participating in social networks (creating user profile, posting messages or other contributions to facebook, twitter, etc.)	i_iusnet	pc_ind
Citizens	Achieved results	Take up of internet services	Looking online for a job or sending a job application	Individuals have used Internet, in the last 3 months, for looking for a job or sending a job application	i_iujob	pc_ind
Citizens	Achieved results	Take up of internet services	Doing an online course (in any subject)	Individuals have used Internet, in the last 3 months, for doing an online course (of any subject)	i_iuolc	pc_ind
Citizens	Achieved results	Take up of internet services	Looking online for information about education, training or course offers	Individuals have used Internet, in the last 3 months, for looking for information about education, training or course offers	i_iueduif	pc_ind
Citizens	Achieved results	Take up of internet services	Taking part in on-line consultations or voting to define civic or political issues	Individuals have used Internet, in the last 3 months, for taking part in on-line consultations or voting to define civic or political issues (e.g. urban planning, signing a petition)	i_iuvote	pc_ind
Citizens	Achieved results	Take up of internet services	Used internet storage space to save documents, pictures, music, video or other files	Used internet storage space to save documents, pictures, music, video or other files	i_cc	pc_ind
Citizens	Achieved results	Digital Skills	Individuals who have written a computer program using a specialised programming language	Individuals who have written a computer program using a specialised programming language. C1:C18	i_cprg	pc_ind
Citizens	Achieved results	Digital Skills	Digital Skills Indicator (internet users)	Persons that have been using internet during last 3 months are attributed a score on four digital competence domains: information, communication, content-creation and problem-solving, depending the activities they have been able to do. The scores are basic, above basic and below basic. Individuals not using internet are classified without digital skills. The four digital competence domains are aggregated in four logical groups.	i-DSK-IU3	Percentage of internet users
Citizens	Achieved results	Digital Skills	Digital Skills Indicator (all individuals)	Persons that have been using internet during last 3 months are attributed a score on four digital competence domains: information, communication, content-creation and problem-solving, depending the activities they have been able to do. The scores are basic, above basic and below basic. Individuals not using internet are classified without digital skills. The four digital competence domains are aggregated in four logical groups.	i-DSK-IND	Percentage of individuals
Citizens	Achieved results	Digital Skills	Individuals with basic or above basic digital skills	Persons that have been using internet during last 3 months are attributed a score on four digital competence domains: information, communication, content-creation and problem-solving, depending the activities they have been able to do. The scores in each domain are basic, above basic and below basic. Individuals not using internet are classified without digital skills. To be classified "basic or above basic" on the overall indicator an individual has to have basic or above basic skills in all the four Digital Competence domains included in the index: information, communication, content-creation and problem-solving.	i_DSK_BAB	pc_ind_iu3
Citizens	Achieved results	Digital Skills	Digital Skills - Information domain	Information processing skills refers to the ability to identify, locate, retrieve, store, organise and analyse digital information, judging its relevance and purpose. The indicator is based on five activities internet users have been able to do online during previous 3 months. The scores are basic, above basic and none. Individuals not using internet are classified without digital skills.	i-DSK-i	Percentage of internet users
Citizens	Achieved results	Digital Skills	Basic or above basic Digital Skills - Information domain	Information processing skills refers to the ability to identify, locate, retrieve, store, organise and analyse digital information, judging its relevance and purpose. The indicator is based on five activities internet users have been able to do online during previous 3 months. The scores are basic, above basic and none. Individuals not using internet are classified without digital skills.	i_DSK_i_BAB	pc_ind
Citizens	Achieved results	Digital Skills	Digital Skills - Communication domain	These skills refer to the ability to communicate in digital environments, share resources through online tools, link with others and collaborate through digital tools, interact with and participate in communities and networks, cross-cultural awareness. The indicator is based on four activities internet users have been able to do online during previous 3 months. The scores are basic, above basic and none. Individuals not	i-DSK-C	Percentage of internet users

Citizens	Achieved results	Digital Skills	Basic or above basic Digital Skills - Communication domain	using internet are classified without digital skills. These skills refer to the ability to communicate in digital environments, share resources through online tools, link with others and collaborate through digital tools, interact with and participate in communities and networks, cross-cultural awareness. The indicator is based on four activities internet users have been able to do online during previous 3 months. The scores are basic, above basic and none. Individuals not using internet are classified without digital skills.	i_DSK_C_BAB	pc_ind_iu3
Citizens	Achieved results	Digital Skills	Digital Skills - Problem solving domain	Problem solving skills refers to the ability to identify digital needs and resources, make informed decisions as to which are the most appropriate digital tools according to the purpose or need, solve conceptual problems through digital means, creatively use technologies, solve technical problems, update one's own and others' competences. The indicator is based on three basic digital problems and familiarity with four online services internet users have been able to do during previous 3 months. The scores are basic, above basic and none. Individuals not using internet are classified without digital skills.	i-DSK-PS	Percentage of internet users
Citizens	Achieved results	Digital Skills	Basic or above basic Digital Skills - Problem solving domain	Problem solving skills refers to the ability to identify digital needs and resources, make informed decisions as to which are the most appropriate digital tools according to the purpose or need, solve conceptual problems through digital means, creatively use technologies, solve technical problems, update one's own and others' competences. The indicator is based on three basic digital problems and familiarity with four online services internet users have been able to do during previous 3 months. The scores are basic, above basic and none. Individuals not using internet are classified without digital skills.	i_DSK_PS_BAB	pc_ind
Citizens	Achieved results	Digital Skills	Digital Skills - Software for content manipulation	Software skills for content manipulation refer to the ability to create and edit new content (from word processing to images and video); integrate and re-elaborate previous knowledge and content; produce creative expressions, media outputs and programming; deal with and apply intellectual property rights and licences. The indicator is based on six activities internet users have been able to do during previous 3 months. The scores are basic, above basic and none. Individuals not using internet are classified without digital skills.	i-DSK-S	Percentage of internet users
Citizens	Achieved results	Digital Skills	Basic or above basic Digital Skills - Software for content manipulation	Software skills for content manipulation refer to the ability to create and edit new content (from word processing to images and video); integrate and re-elaborate previous knowledge and content; produce creative expressions, media outputs and programming; deal with and apply intellectual property rights and licences. The indicator is based on six activities internet users have been able to do during previous 3 months. The scores are basic, above basic and none. Individuals not using internet are classified without digital skills.	i_DSK_S_BAB	pc_ind
Citizens	Achieved results	Digital Skills	Digital skills indicator (internet users) - pilot 2012/2014	Persons that have been using internet during last 3 months are attributed a score on four digital competence domains: information, communication, content-creation and problem-solving, depending the activities they have been able to do. The scores are basic, above basic and below basic. Individuals not using internet are classified without digital skills. The four digital competence domains are aggregated in four logical groups.	digskillindex	Percentage of internet users
Citizens	Achieved results	Digital Skills	Individuals with basic or above basic digital skills - pilot 2012/2014	Persons that have been using internet during last 3 months are attributed a score on four digital competence domains: information, communication, content-creation and problem-solving, depending the activities they have been able to do. The scores in each domain are basic, above basic and below basic. Individuals not using internet are classified without digital skills. To be classified "basic or above basic" on the overall indicator an individual has to have basic or above basic skills in all the four Digital Competence domains included in the index: information, communication, content-creation and problem-solving.	digskillindex_ basicandabove	pc_ind
Citizens	Achieved results	Digital Skills	ICT Access - Computer Ownership	Percentage of households with Internet acces	ict_access	
Citizens	Achieved results	eHealth	Seeking online information about health	Individuals using internet in the last 3 months, seeking information about health: injury, disease, nutrition, improving health, etc.	i_ihif	pc_ind
Citizens	Achieved results	Security and Privacy	Individuals experienced financial loss	Individuals experienced financial loss due to fraudulent payment (credit or debit) card use OR as a result of receiving fraudulent messages ('phishing') or getting redirected to fake websites asking for personal information ('pharming').	I_SECFL	pc_ind
Citizens	Achieved results	Security and	Individuals experienced abuse	Individuals experienced abuse of personal information sent on the Internet and/or other privacy violations (e.g. abuse of pictures, videos, personal data uploaded on	I_SECPIF1	pc_ind

		Privacy	of personal information and/or other privacy violations	community websites)		
Firms	Enablers	Telecom sector	Total investment in networks by the electronic communications sector	Total investment includes both tangible and intangible investment in telecommunication networks (without license fees) by all telecom operators	tel_inv	million_euro
Firms	Enablers	Mobile market	Enterprises providing portable devices to some of their persons employed	The devices (portable computers, tablets, smartphones, PDA phones, etc.) should be provided for business use and the enterprises pay for all or at least up to a limit the subscription and the use costs.	e_pmd	pc_ent
Firms	Enablers	eCommerce	Enterprises using any computer network for sales (at least 1%)	The sales realised, during the previous calendar year, via any computer networks should represent at least 1% of the total turnover value (in monetary terms, excluding VAT). Computer networks include websites, EDI-type systems and other means of electronic data transfer, excluding manually typed e-mails.	e_esell	pc_ent
Firms	Enablers	eBusiness	Enterprises providing persons employed a remote access to the enterprise's e-mail system, documents or applications		e_ra	pc_ent
Firms	Enablers	eBusiness	Enterprises providing portable devices to more than 20% of their employed persons	The devices (portable computers, tablets, smartphones, PDA phones, etc.) should be provided for business use and the enterprises pay for all or at least up to a limit the subscription and the use costs.	e_empmd_gt20	pc_ent
Firms	Enablers	eBusiness	Persons employed which were provided a portable device by their employer (business sector)	The devices (portable computers, tablets, smartphones, PDA phones, etc.) should be provided for business use and the enterprises pay for all or at least up to a limit the subscription and the use costs. Are included only the enterprises with 10 or more persons employed, from all manufacturing and service sectors, excluding the financial sector.	P_EMPMD	pc_emp
Firms	Enablers	eBusiness	Enterprises using mobile Internet to run business applications	Mobile connection to the Internet for business use to use dedicated business software applications	e_pmd_app	pc_ent
Firms	Enablers	eBusiness	Enterprises paying to advertise on the internet	Enterprises paying to advertise on the internet	e_ads	pc_ent
Firms	Enablers	eBusiness	Enterprises analysing big data from any data source	Analyse big data from any data source	e_bd	pc_ent
Firms	Enablers	Digital Skills	Persons employed using computers with access to the Web at work (business sector)	The computers (desktop, laptop, smartphones, etc.) should have access to the World Wide Web and be used at least once a week. Are included only the enterprises with 10 or more persons employed, from all manufacturing and service sectors, excluding the financial sector.	P_IUSE	pc_emp
Firms	Enablers	Digital Skills	Science and technology graduates	Tertiary graduates in science and technology per 1 000 inhabitants aged 20-29 years includes new tertiary graduates in a calendar year from both public and private institutions completing graduate and post graduate studies compared to an age group that corresponds to the typical graduation age in most countries.	st_grad	nb_x1000inh_20_29
Firms	Enablers	ICT Specialist	Enterprises employing ICT specialists	ICT specialists are employees for whom ICT is the main job. For example, to develop, operate or maintain ICT systems or applications.	E_ITSP2	pc_ent
Firms	Enablers	ICT Specialist	Enterprises reporting hard-to-fill vacancies for jobs requiring ICT specialist skills	Hard-to-fill vacancies during the previous calendar year refer to a range of situations in which enterprises find it difficult to find persons with particular skills (hard-to-fill vacancies due to skills shortage).	E_ITSPVAC2	PC_ENT_ITSPRCR2
Firms	Enablers	ICT Specialist	Persons Employed with ICT Specialist Skills (broad measure)	The definition of the ICT Specialists' occupations is based on the new ISCO-08 classification. It includes ICT service managers (code 133), ICT professionals (25), ICT technicians (35) and some other groups, from electronic and telecomunnications engineers (215*) up to ICT installers and servicers (7422). Where 4-digit data was not available, the share of computing graduates in the corresponding 3-digit data was estimated. See metadata fiche for a complete explanation of the methodology (Eurostat table isoc_sks_itspt)	ict_spec3_broad	th_ind
Firms	Enablers	ICT Specialist	Enterprises where ICT functions are mainly performed by external suppliers	The majority of ICT functions, out of a list of seven, are mainly performed by external suppliers and not by own employees or by ICT specialist in parent or affiliate enterprises. The functions include: maintenance of ICT infrastructures, support for office software, development and support for web solutions or business management software/systems (e.g. ERP, CRM, HR, databases), security and data protection.	E_IT_MEXT	pc_ent
Firms	Enablers	ICT Specialist	Enterprise provided training to their personnel to	Detailed results are available in the Eurostat table ISOC_SKE_ITTN2.	E_ITT2	pc_ent

			develop/upgrade their ICT skills			
Firms	Enablers	Security and Privacy	Enterprises tracking internet users for targeted advertising	Pay to advertise on the internet, based on the tracking of internet users' past activities or profile	e_ads_trk	pc_ent
Firms	Enablers	Security and Privacy	Enterprises with a formally defined ICT security policy		E_SECPOL1	pc_ent
Firms	Enablers	ICT sector	Import of ICT goods and services	ICT goods include: Computers and peripheral equipment, Communication equipment, Consumer electronic equipment, Electronic components and Miscellaneous. ICT services include: Communications services, Computer and information services. The value of import cover both intra- and extra- EU.	ict_imp	pc_imp
Firms	Enablers	ICT sector	Employment of the ICT sector	Number of persons employed. In the System of National Accounts (SNA) this is defined as all persons, both employees and self-employed, engaged in some productive activity that falls within the production boundary of the SNA and that is undertaken by a resident institutional unit.	employment_ict	thousand_ind
Firms	Enablers	ICT sector	Business R&D expenditure of the ICT sector	Intramural expenditures on R&D performed within business enterprise sector during a specific period, whatever the source of funds (Frascati Manual).	bs_rd_expen_ict	million_euro
Firms	Achieved results	Telecom sector	Total revenues of the electronic communications sector	Total includes wholesale and retail revenues from electronic communications perceived in the reference year by all telecom operators (VAT excluded)	tel_rev	million_euro
Firms	Achieved results	Telecom sector	Fixed voice termination rate	Wholesale call termination charges of the incumbent operator in fixed voice tecephony for local calls	tel_ftr	eurocent
Firms	Achieved results	Telecom sector	Local Loop Unbundling: total monthly charge	The monthly total wholesale cost for Local Loop Unbundling charged by incumbent operators, Calculated as the sum of the monthly charge and 1/36 of the conncetion fee	tel_llu	euro
Firms	Achieved results	eCommerce	Individuals ordering goods or services online	Individuals carrying out this activity over the internet in the last 12 months, for private use.	i_blt12	pc_ind
Firms	Achieved results	eCommerce	Individuals ordering goods or services online, from sellers from other EU countries	Individuals that ordered goods or services for private use over the Internet in the last 12 months from sellers from other EU countries	i_bfeu	pc_ind
Firms	Achieved results	eCommerce	Individuals ordering physical goods online	Individuals that have ordered online any of the following physical goods: food/groceries, household goods, medicine, clothes/sports, computer hardware, electronic equipment.	i_bpgood	pc_ind
Firms	Achieved results	eCommerce	Individuals ordering services online	Individuals that have ordered online any of the following services: telecommunications services, share/insurance/financial, holiday accomodation, travel arrangements, tickets for events.	i_bserv	pc_ind
Firms	Achieved results	eCommerce	Individuals ordering content or software that were delivered or upgraded online	The online content and software include: films, music, books, magazines, e-learning material, computer software, video games, that were ordered/bought over the Internet in the last 12 months, for non-work use.	i_bgoodo	pc_ind
Firms	Achieved results	eCommerce	Individuals ordering content or software delivered online or offline	Online purchases: films/music or books/magazines/e-learning material or computer software	i_bgood	pc_ind
Firms	Achieved results	eCommerce	Individuals selling goods or services online (e.g. via auctions)	Individuals have used Internet, in the last 3 months, for selling goods and services (e.g. via auctions)	i_iusell	pc_ind
Firms	Achieved results	eCommerce	Individuals who did not encounter problems when buying/ordering goods or services over the internet for private use	Individuals who had no problems buying/ordering goods or services over the internet for private use	i_barr1x	pc_ind
Firms	Achieved results	eCommerce	Total electronic sales by enterprises, as a % of their total turnover	The value of sales realised, during the previous calendar year, via any computer networks in % of the total turnover value (in monetary terms, excluding VAT). Computer networks include websites, EDI-type systems and other means of electronic data transfer, excluding manually typed e-mails.	e_eturn	pc_turn
Firms	Achieved results	eCommerce	Enterprises having done	The sales have been realised, during the previous calendar year, via any computer	e_aeseu	pc_ent_aesell

			electronic sales to other EU countries in the last calender year	networks (in monetary terms, excluding VAT). Computer networks include websites, EDI-type systems and other means of electronic data transfer, excluding manually typed e-mails.		
Firms	Achieved results	eCommerce	Enterprises exploiting the "Businees to Consumers" opportunities of web sales	Enterprises where web sales are more than 1% of total turnover and B2C web sales more than 10% of the web sales	E_AWS_GT1_ B2C_GT10WS	pc_ent
Firms	Achieved results	eBusiness	Enterprises that share internally electronic information with an ERP	Have in use an ERP-Enterprise resource planning software package, to share information between different functional areas (e.g. accounting, planning, production, marketing).	E_ERP1	pc_ent
Firms	Achieved results	eBusiness	Enterprises using Customer Relationship Management (CRM) software	CRM refers to the use of any software application used for the analysis of information about clients for marketing purposes.	e_crman	pc_ent
Infrastructure	Achieved results	Broadband take-up and coverage	Fixed broadband subscriptions	Number of fixed broadband subscriptions (lines).	bb_lines	nbr_lines
Infrastructure	Achieved results	Broadband take-up and coverage	Fixed broadband take-up (subscriptions/100 people)	Number of fixed broadband subscriptions (lines) per 100 people. Penetration of fixed broadband.	bb_penet	subs_per_100_pop
Infrastructure	Achieved results	Broadband take-up and coverage	DSL subscriptions share in fixed broadband	Share of DSL (Digital Subscriber Line) in total fixed broadband subscriptions.	bb_dsl	pc_lines
Infrastructure	Achieved results	Broadband take-up and coverage	Households having a broadband connection	Broadband connection used by the household includes: DSL, wired fixed (cable, fiber, Ethernet, PLC), fixed wireless (satellite, WiFi, WiMax) and mobile wireless (3G/UMTS).	h_broad	pc_hh
Infrastructure	Achieved results	Broadband take-up and coverage	Households with fixed broadband connection	Household internet connection type: fixed broadband	h_bbfix	pc_hh
Infrastructure	Achieved results	Broadband take-up and coverage	Enterprises having a fixed broadband connection	Fixed broadband connections include DSL, xDSL, cable leased lines, Frame Relay, Metro-Ethernet, PLC-Powerline communications, fixed wireless connections, etc.	e_broad	pc_ent
Infrastructure	Achieved results	Broadband take-up and coverage	Enterprises having a fast fixed broadband connection	The maximum contracted download speed of the fastest fixed internet connection is at least 30 Mb/s	e_ispdf_ge30	pc_ent
Infrastructure	Achieved results	Broadband speeds and prices	Share of fixed broadband subscriptions >= 2 Mbps - Advertised download speed	Based on advertised download speeds	bb_speed2	pc_lines
Infrastructure	Achieved results	Broadband speeds and prices	Share of fixed broadband subscriptions >= 10 Mbps - Advertised download speed	Based on advertised download speeds	bb_speed10	pc_lines
Infrastructure	Achieved results	Broadband speeds and prices	Share of fixed broadband subscriptions >= 30 Mbps - Advertised download speed	Based on advertised download speed	bb_speed30	pc_lines
Infrastructure	Achieved results	Broadband speeds and prices	Share of fixed broadband subscriptions >= 100 Mbps - Advertised download speed	Based on advertised download speeds	bb_speed100	pc_lines
Infrastructure	Achieved results	Broadband speeds and prices	Households that have no access to Internet at home, because the costs are too high	Households that have no access to Internet at home, because the costs are too high	h_xcost	pc_hh
Infrastructure	Achieved results	Mobile market	Total number of subscriptions (SIM cards)	Mobile subscriptions are defined as the number of active SIM cards. It includes both voice and data services, installed in telephones, modem, usb keys or other devices.	mob_subs	nbr_subs
Infrastructure	Achieved results	Mobile market	Take-up of mobile - active SIM cards for voice or data	Number of active SIM cards divided by population. It includes both voice and data services, installed in telephones, modem, usb keys or other devices.	mob_penet	subs_per_100_pop
Infrastructure	Achieved results	Mobile market	Take-up of mobile broadband (subscriptions/100 people)	Mobile Broadband penetration is defined as the number of active mobile broadband SIM cards per 100 people.	mbb_penet	subs_per_100_pop
Infrastructure	Achieved results	Mobile market	Market share of leading operator (in % of active SIM	Market share of the market leader based on the number of active SIM cards	mob_ms	pc_subs

			cards)			
Infrastructure	Achieved results	Mobile market	Individuals accessing the Internet through a mobile phone via UMTS (3G)	Individuals using a mobile phone or smart phone to access the internet, in the last 3 months. Since 2011 the question specify "away from home or work". Until 2012 the question was limited to "via UMTS, HSDPA (3G or 3G+) connections".	i_iu3g	pc_ind
Infrastructure	Achieved results	Mobile market	Average Revenue per User (ARPU) in the Retail Mobile Market	Total retail mobile revenues divided by number of active SIM cards	mob_arpu	euro
PA	Enablers	eGovernment	Online Service Completion	Share of the steps in a Public Service life event that can be completed online (Online availability sub-indicator for User centricity of the eGovernment benchmark)	e_gov_osc	eGov_score
PA	Enablers	eGovernment	Pre-filled forms	Amount of data that is pre-filled in Public Services' online forms (Authentic sources Key Enabler indicator of eGovernment benchmark)	e_gov_pff	eGov_score
PA	Enablers	eGovernment	Laws relating to ICTs	Development of country's laws relating to the use of ICTs (e.g., e-commerce, digital signatures, consumer protection)?	e_ict_laws	Score (now %, it was 1 to 7)
PA	Enablers	eGovernment	Government success in ICT promotion	How successful is the government in promoting the use of ICTs	ict_gov_promo	Score (now %, it was 1 to 7)
PA	Enablers	eGovernment	Importance of ICTs to government vision of the future	To what extent does the government have a clear implementation plan for utilizing ICTs to improve your country's overall competitiveness?	ict_gov_vision	Score (now %, it was 1 to 7)
PA	Enablers	ICT in Education	Computers for educational purposes	Computers used for educational purposes include desktop, laptop, netbook or tablet computer, whether or not connected to the internet	eun_computers	Number per 100 students
PA	Enablers	ICT in Education	Schools having a website	Own home page or web site available at school.	eun_web	Percentage of schools
PA	Enablers	ICT in Education	Internet access in schools	Possibility to use internet in schools for educational pourpose	schools_internet	Score (now %, it was 1 to 7)
PA	Enablers	EU Research and Development Programs	GBAORD - Government budget appropriations or outlays for research and development	GBAORD include all appropriations (government spending) given to R&D in central (or federal) government budgets. Provincial (or State) government posts are only included if the contribution is significant. Local government funds are excluded	gbaord	million_euro
PA	Enablers	EU Research and Development Programs	Public ICT R&D spending (GBAORD in the field of ICT)	Estimate of the ICT share in existing disaggregated GBAORD data, based on the assumption that the share of research in the ICT field in GBAORD expenditure is proportional to the share of ICT specialists in the R&D labour cost. Methodology developped and implemented by JRC-IPTS.	gbaord_ict	euro_x_million_gbaord
PA	Enablers	EU Research and Development Programs	Total EC funding to participants in H2020 ICT projects	Value of European Commission funding committed through grant agreements signed, during the reference year, with participants in ICT research projects under Horizon 2020 (LEIT ICT, Excellent Science, Societal Challenges 1, 6 and 7). Projects under negotiation are not included.	H2020_EC_funding	euro_x_million_of_gdp
PA	Enablers	EU Research and Development Programs	Total cost of H2020 ICT projects	Value of the total cost of the ICT research projects for which a grant agreement was signed in the reference year, under the Horizon 2020 LEIT ICT, Excellent Science, Societal Challenges 1, 6 and 7). Total cost of the project is the sum of participants' total costs.	H2020_TOTcost	euro
PA	Enablers	EU Research and Development Programs	H2020 effective cofinancing rate	The cofinancing rate is the % of projects total costs which are covered by EC funding grants.	H2020_cofin	pc_total_cost
PA	Enablers	EU Research and Development Programs	Number of distinct organisations participating in H2020 ICT projects	Organisations participating in H2020 ICT projects during the reference year.	H2020_ organisations	nbr_ organisations
PA	Enablers	EU Research and Development Programs	Number of distinct organisations participating in H2020 ICT projects for the first time	Organisations participating for the first time in H2020 ICT calls, and which have not participated in FP7 ICT calls during 2007-2013 period.	H2020_newENTRY	nbr_ organisations
PA	Enablers	EU Research and Development Programs	EC funding to participants in FP7-ICT projects	Value of European Commission funding committed through grant agreements signed, during the reference year, with participants in ICT research projects under the EU's Seventh Framework Programme (FP7). Projects under negotiation are not included.	FP7ICT_EC_ funding	pc_gva
Citizens	Achieved results	Security and Privacy	Individuals caught a virus or other computer infection	Individuals caught a virus or other computer infection (e.g. worm or Trojan horse) resulting in loss of information or time	I_SECVIR1	pc_ind

			resulting in loss of information or time			
Citizens	Achieved results	Security and Privacy	Individuals who know that cookies can be used to trace movements of people on the internet	Individuals who know that cookies can be used to trace movements of people on the internet	I_COOK	pc_ind
Citizens	Achieved results	Security and Privacy	Individuals using anti-tracking software	Individuals using anti-tracking software	i_atsw	pc_ind
Citizens	Achieved results	Security and Privacy	Individuals not allowing use of personal information for advertising	Individuals not allowing use of personal information for advertising	i_piacadv	pc_ind
Firms	Achieved results	eBusiness	Enterprises sharing electronic information on the supply chain	The indicator refers to sending/receiving all type of information on the supply chain (e.g. inventory levels, production plans, forecasts, progress of delivery) via computer networks or via websites, but excluding manually typed e-mail messages.	e_sisc	pc_ent
Firms	Achieved results	eBusiness	Enterprises sending e-invoices (derived indicator)	The indicator refers to sending invoices in an agreed standard format (as EDIFACT, XML, etc) which allows their automatic processing, without the individual message being manually typed.	e_invsnd	pc_ent
Firms	Achieved results	eBusiness	Enterprises having a web site or homepage		E_WEB	pc_ent
Firms	Achieved results	eBusiness	Enterprises having a website with some sofisticated functionalities	Website having at least one of the following four functionalities : product catalogues or price lists (webacc), possibilities for visitors to customise or design the products (webctm), order tracking available online (webot) or personalised content in the website for regular/repeated visitors (webper).	e_webf2	pc_ent
Firms	Achieved results	eBusiness	Enterprises with High levels of Digital Intensity	The Digital Intensity score is based on counting how many out of 12 technologies are used by each enterprise. High levels are attributed to those enterprises using at least 7 of the listed digital technologies.	e_di_hivhi	pc_ent
Firms	Achieved results	eBusiness	Enterprises with Very Low level of Digital Intensity	The Digital Intensity score is based on counting how many out of 12 technologies are used by each enterprise. Very Low levels are attributed to those enterprises using no more than 3 of the listed digital technologies.	e_di_vlo	pc_ent
Firms	Achieved results	eBusiness	Digital Intensity score for Enterprises	The Digital Intensity score is based on counting how many out of 12 technologies are used by each enterprise. Then they are divided into four clusters of digital intensity: Very Low (scores 0-3), Low (score 4-6), High (score 7-9), Very High (score 10-12).	edigint2015	Percentage of enterprises
Firms	Achieved results	eBusiness	Enterprises using Radio Frequency Identification (RFID) technologies	RFID tags or transponders are devices that can be applied to or incorporated into a product or object and transmits data via radiowaves. The indicator includes their use for person identification, for tracking of supply chain and inventory or for after-sales product identification.	e_rfid	pc_ent
Firms	Achieved results	eBusiness	Enterprises using RFID technologies for person identification or access control	RFID tags or transponders are devices that can be applied to or incorporated into a product or object and transmits data via radiowaves.	e_rfac	pc_ent
Firms	Achieved results	eBusiness	Enterprises using RFID for product identification	RFID tags or transponders are devices that can be applied to or incorporated into a product or object and transmits data via radiowaves. The indicator includes their use for tracking of supply chain and inventory or for after-sales product identification.	e_rfpsas	pc_ent
Firms	Achieved results	eBusiness	Enterprises using social media	Enterprises using at least one of the following social media: social networks, enterprise's blog or microblog, multimedia content sharing websites, wiki based knowledge sharing tools. Using social media means that the enterprise have a user profile, an account or a user license depending on the requirements and the type of the social media.	e_sm_any	pc_ent
Firms	Achieved results	eBusiness	Use two or more social media	Enterprises using two or more of the following social media: social networks, enterprise's blog or microblog, multimedia content sharing websites, wiki based knowledge sharing tools. Using social media means that the enterprise have a user profile, an account or a user license depending on the requirements and the type of the social media.	e_sm_ge2	pc_ent
Firms	Achieved results	eBusiness	Buy Cloud Computing services used over the internet	Cloud computing refers to purchased ICT services that have all of the following characteristics: are delivered from servers of service providers; can be easily scaled up or down; can be used on-demand by the user without human interaction with the service provider; are paid for, either per user, by capacity used, or they are pre-paid.	e_cc	pc_ent

Firms	Achieved results	eBusiness	Buy Cloud Computing services of medium-high sophistication	Enterprises purchasing at least one of the following cloud computing services: hosting of the enterprise's database, accounting software applications, CRM software, computing power.	e_CC_GE_ME	pc_ent
Firms	Achieved results	Digital Skills	workers who judge their current ICT skills insufficient for changing job within a year	Individuals with an occupation as employees, self-employed or family workers, were asked if they judge their current computer or Internet skills to be sufficient (yes/not) if they were to look for a job or change job within a year.	i_cisk_sfjobx	pc_ind
Firms	Achieved results	Security and Privacy	Security concerns kept individual from ordering or buying online	Security concerns kept individual from ordering or buying goods or services for private use	I_SBGOOD	pc_ind
Firms	Achieved results	Security and Privacy	Enterprises advertising online based on the geolocation of internet users	Pay to advertise on the internet, based on the geolocation of internet users	e_ads_loc	pc_ent
Firms	Achieved results	ICT sector	Export of ICT goods and services	ICT goods include: Computers and peripheral equipment, Communication equipment, Consumer electronic equipment, Electronic components and Miscellaneous. ICT services include: Communications services, Computer and information services. The value of exports cover both intra- and extra- EU.	ict_exp	pc_exp
Firms	Achieved results	ICT sector	Value added of the ICT sector	Value added. In the System of National Accounts it is defined as the value of output less the value of intermediate consumption; it is a measure of the contribution to GDP made by an individual producer, industry or sector.	val_add_ict	million_euro
Firms	Achieved results	ICT sector	Labour productivity of the ICT sector (per person)	Is defined as value added per unit of labour input (persons employed).	labour_prod_ict	thousand_euro
Firms	Achieved results	eBusiness	Enterprises using any computer network for purchases (at least 1%)	The purchases realised, during the previous calendar year, via any computer networks should represent at least 1% of the total purchases value (in monetary terms, excluding VAT). Computer networks include websites, EDI-type systems and other means of electronic data transfer, excluding manually typed e-mails.	e_ebuy	pc_ent
Infrastructure	Enablers	Broadband take-up and coverage	Standard fixed broadband coverage/availability (as a % of households)	Coverage is a supply indicator defined as the percentage of Households living in areas served by xDSL, cable (basic and NGA), FTTP or WiMax networks	bb_scov	pc_hh_all
Infrastructure	Enablers	Broadband take-up and coverage	Rural standard fixed broadband coverage (as a % of households)	Coverage is a supply indicator defined as the percentage of Households living in areas served by xDSL, cable (basic and NGA), FTTP or WiMax networks. Rural areas are defined as those with less than 100 people per km2.	bb_srcov	pc_hh_all
Infrastructure	Enablers	Broadband take-up and coverage	NGA broadband coverage/availability (as a % of households)	Coverage is a supply indicator defined as the percentage of Households living in areas served by NGA. Next Generation Access includes the following technologies: FTTH, FTTB, Cable Docsis 3.0, VDSL and other superfast broadband (at least 30 Mbps download)	bb_ngacov	pc_hh_all
Infrastructure	Enablers	Broadband take-up and coverage	New entrants' share in fixed broadband subscriptions	Market share based on fixed broadband subscriptions (lines). New entrants mean operators that did not enjoy special and exclusive rights or de facto monopoly for the provision of voice telephony services before the liberalisation.	bb_ne	pc_lines
Infrastructure	Enablers	Broadband speeds and prices	Actual download speed of fixed broadband subscriptions	Average Download Speed during peak periods (ACTSPEED), measured with a specially configured hardware device (SamKnows Whitebox), which runs a series of purpose-built tests to measure various aspect of Internet performance. The measured speed refers to a sample of subscriptions using a similar technology offered by internet service providers. Offers are not weigthed with market shares, so the measured speed cannot be interpreted as the average experienced by consumers	actspeed	pc_nomspeed
Infrastructure	Enablers	Broadband speeds and prices	Monthly price of standalone internet access	Monthly price of standalone Fixed Broadband Internet Access offers, including value added tax, excluding the additional cost of telephony or cable line (if any). The minimum and median prices refer to the group of similar subscriptions offered by internet service providers. Offers are not weigthed with market shares, so the offers' median price cannot be interpreted as the median price paid by consumers	price_internet_only	minimum_euro_ppp
Infrastructure	Enablers	Broadband speeds and prices	1d1 Fixed BB-Price	Monthly cost of the least expensive fixed broadband subscription with speed of 12 to 30 Mbps	DESI_1D1_FBBP	pc_dispo_income
Infrastructure	Enablers	Broadband speeds and prices	Monthly price of Fixed Broadband Internet Access offers including Fixed	Monthly price of Fixed Broadband Internet Access offers including Fixed Telephony, including value added tax, excluding the aditional cost of telephony or cable line (if any). The minimum and median prices refer to the group of similar subscriptions offered by internet service providers. Offers are not weigthed with market shares, so	Price_Internet_ Fixed_Tel	Minimum price in euros, corrected using Purchasing Power Parities

			Telephony	the offers' median price cannot be interpreted as the median price paid by consumers		
Infrastructure	Enablers	Broadband speeds and prices	Monthly price of Internet Acccess + Fixed Telephony + TV bundles	Monthly price of Fixed Broadband Internet Access offers including Fixed Telephony and TV (analogue or digital television service), including value added tax, excluding the aditional cost of telephony or cable line (if any). The minimum and median prices refer to the group of similar subscriptions offered by internet service providers. Offers are not weigthed with market shares, so the offers' median price cannot be interpreted as the median price paid by consumers	Price_Internet_Fixed_Tel_TV	Minimum price in euros, corrected using Purchasing Power Parities
Infrastructure	Enablers	Broadband speeds and prices	Affordability of standalone Fixed Internet Access (minimum price offer)	Affordability is defined as 12 times the monthly price divided by the "real adjusted gross disposable income of households per capita" of the previous year. Disposable income data come from Eurostat table tec00113. Monthly price of standalone Fixed Broadband Internet Access offers, include value added tax, exclude the additional cost of telephony or cable line (if any), and refers to the minimum price in the group of similar subscriptions offered by internet service providers	Afford_Internet_only_minPPP	pc_dispo_income
Infrastructure	Enablers	Mobile market	Advanced 3G mobile broadband (HSPA) coverage (as a % of households)	Coverage is a supply indicator defined as the percentage of Households living in areas covered by advanced third generation mobile broadband (HSPA protocol)	mbb_hspacov	pc_hh_all
Infrastructure	Enablers	Mobile market	4G mobile broadband (LTE) coverage (as a % of households)	Coverage is a supply indicator defined as the percentage of Households living in areas covered by advanced fourth generation mobile broadband (LTE protocol)	mbb_ltecov	pc_hh_all
Infrastructure	Enablers	Mobile market	1b2 4G Coverage	Percentage of populated areas coverage by 4G - measured as the average coverage of telecom operators in each country	DESI_1B2_4G	pc_hh_all
Infrastructure	Enablers	Mobile market	Mobile roaming price per minute	Average retail price per minute (in €-cents) on Eurotariff for intra-EEA roaming voice calls made	mob_roam	eurocent
Infrastructure	Enablers	Mobile market	Spectrum assigned for wireless broadband in EU harmonised bands	Amount of spectrum assigned by Member States for wireless mobile broadband comunications (WBB) within the ranges harmonised by the European Union. Charts allow to compare with the total value of EU HARMONISED bands and with a simple EU AVERAGE of countries assignements. The policy target is to harmonise and assign 1200 MHz to WBB.	spectrum_WBB	pc_spectrum_ assigned
Infrastructure	Enablers	Mobile market	Mobile voice termination rate	Wholesale call termination charges in mobile voice tecephony	mob_mtr	eurocent
Infrastructure	Enablers	Internet usage	IPv6 readiness - websites having a AAAA coverage in DNS records (as % of most visited websites)	IPv6 ready websites are those having at least one AAAA in their DNS records (means the website is visible/can reply to users having an IPv6 connectivity). Tests are done every trimester through a script run by the IPv6 Observatory study on the 1 million most visited websites list provided by Alexa. Websites are attributed to countries on the basis of their main operation location as provided by MaxMind GeoIP database.	AAAA_cov	pc_websites
PA	Enablers	EU Research and Development Programs	Total cost of FP7-ICT projects	Value of the total cost of the ICT research projects for which a grant agreement was signed in the reference year, under the EU's Seventh Framework Programme (FP7). Total cost of the project is the sum of participants' total costs.	FP7ICT_TOTcost	euro
PA	Enablers	EU Research and Development Programs	FP7 EC effective cofinancing rate	The cofinancing rate is the % of projects total costs which are covered by EC funding grants. Figures include all partners and third parties (as subcontractors).	FP7ICT_cofin	pc_total_cost
PA	Enablers	EU Research and Development Programs	Total number of participations in FP7-ICT projects	Each project has multiple partners participating and each partner can participate in multiple projects. For each participation there could be an EC funding (some participations do not receive EC funding). Third parties are included as partners, receiveing or not EU funding.	FP7ICT_particip	nbr_ participations
PA	Enablers	EU Research and Development Programs	Average EC funding per participation in FP7-ICT projects	EC funding is the funding committed by the European Commission through grant agreements signed during the reference year. The indicator measure the average EC funding attributed to each partner participation in a specific project.	FP7ICT_afxp	euro
PA	Enablers	EU Research and Development Programs	Number of distinct organisations participating in FP7-ICT projects for the first time	The first call of FP7 ICT was in 2007 and all participants are considered as new ones. For each of the following years are counted only the organisations participating for the first time in FP7 ICT calls.	FP7ICT_newENTRY	nbr_organisations
PA	Enablers	EU Research and Development Programs	Number of distinct organisations participating in FP7-ICT projects	Organisations participating in FP7 ICT calls for research projects (Cooperation and Capacities and e-infrastructures programs) during the reference year.	FP7ICT_ organisations	nbr_ organisations
PA	Enablers	eGovernment	Open Data Barometer	Availability and impact of Open Data	open_data_	%

					barometer	
PA	Achieved results	eGovernment	Individuals interacting online with public authorities, last 12 months	Individuals have used Internet, in the last 12 months, for interaction with public authorities. It includes obtaining information from public authorities web sites, OR downloading official forms OR sending filled in forms.	i_iugov12	
PA	Achieved results	eGovernment	Individuals submitting completed forms to public authorities, over the internet, last 12 months		i_igov12rt	pc_ind_ilt12 pc_igov12nrt
PA	Achieved results	eGovernment	Individuals interacting online with public authorities, last 12 months	Individuals have used Internet, in the last 12 months, for interaction with public authorities. It includes obtaining information from public authorities web sites, OR downloading official forms OR sending filled in forms.	i_iugov12	pc_ind_ilt12
PA	Achieved results	eGovernment	E Participation Index	Highlights how much a country's citizen accepts online tools provided by the government. Interesting to compare e-gov with e-participation score	e_participation	
PA	Achieved results	eGovernment	Government effectiveness	Reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	e_gov_ effectiveness	Score (now %, it was -2,5 to 2,5)
PA	Achieved results	eGovernment	ICT use and government efficiency	In your country, to what extent does the use of ICTs by the government improve the quality of government services to the population?	e_gov_efficiency	Score (now %, it was 1 to 7)
PA	Achieved results	eGovernment	Impact of ICTs on access to basic services	ICTs enabling access for all individuals to basic services (e.g., health, education, financial services, etc.)	ict_imp_ basic_services	Score (now %, it was 1 to 7)
PA	Achieved results	eHealth	Making an appointment with a practitioner via a website	Individuals have used Internet, in the last 3 months, for making an appointment with a practitioner via a website (e.g. of a hospital or a health care centre)	I_IUMAPP	pc_ind
PA	Achieved results	eHealth	GPs using electronic networks to transfer prescriptions to pharmacists	Percentatge of general practitioners using electronic networks to transfer prescriptions to pharmacists	HIE_use_pharm	pc_gp
PA	Achieved results	eHealth	GPs exchanging medical patient data with other healthcare providers and professionals	Percentatge of general practitioners using electronic networks to exchange medical patient data with other healthcare providers and professionals	HIE_use_ex_admin	pc_gp
PA	Achieved results	eHealth	On-line booking of appointments	Possibility to book online doctor's appointments	e_online_booking	Score (now %, it was 1 to 3, 1:best, 3:worst)
PA	Achieved results	eHealth	ePrescriptions	Spread of ePrescription services across the country	e_prescriptions	Score (now %, it was 1 to 3, 1:best, 3:worst)
PA	Achieved results	Security and Privacy	Global Security Index	A composite index combining 24 indicators into one benchmark measure to monitor and compare the level of Member States' cybersecurity commitment.	global_sec_index	
PA	Achieved results	EU Research and Development Programs	Total number of participations in H2020 ICT projects	Each project has multiple partners participating and each partner can participate in multiple projects. For each participation there could be an EC funding (some participations do not receive EC funding).	H2020_particip	
PA	Achieved results	EU Research and	Average EC funding per	EC funding is the funding committed by the European Commission through grant agreements signed during the reference year. The indicator measures the average EC	H2020ICT_afxp	nbr_ participations euro

		Development Programs	participation in H2020 ICT projects	funding attributed to each partner participation in a specific project.		
PA	Achieved results	eGovernment	Open Data	Score in the European PSI Scoreboard measuring the status of Open Data and PSI re-use throughout the EU	DESI_5A4_ OPENDATA	od_score

Annex II: Overview of Indexes

Autor	Report	Index	Year	Link
World Economic Forum	The Global Information Technology Report	The Networked Readiness Index	2016	PDF
World Economic Forum	The Global Information Technology Report	The Networked Readiness Index	2015	HTML
World Economic Forum	The Global Information Technology Report	The Networked Readiness Index	2014	HTML
World Economic Forum	The Global Information Technology Report	The Networked Readiness Index	2013	JTML
World Economic Forum	The Global Information Technology Report	The Networked Readiness Index	2012	HTML
World Economic Forum	The Global Competitiveness Report 2016-2017	—	2016	HTML
Huawei	—	Global Connectivity Index	2016	PDF
World Bank Group	Doing Business	—	2017	HTML
World Bank Group	Doing Business	—	2016	HTML
World Bank Group	Doing Business	—	2015	HTML
World Bank Group	Doing Business	—	2014	HTML
World Bank Group	Doing Business	—	2013	HTML
World Bank Group	Doing Business	—	2012	HTML
The Media Institute	—	Net Vitality Index	2015	PDF
WIPO	—	The Global Innovation Index	2016	HTML
WIPO	—	The Global Innovation Index	2014	PDF
WIPO	—	The Global Innovation Index	2013	PDF
WIPO	—	The Global Innovation Index	2012	PDF
WIPO	—	The Global Innovation Index	2011	PDF
Mastercard, Datacash, Tufts University	—	Digital Evolution Index	2014	HTML
International Telecommunication Union	Measuring the Information Society Report	The ICT Development Index	2016	HtTML
International Telecommunication Union	Measuring the Information Society Report	The ICT Development Index	2014	PDF
European Commission	Regional Innovation Scoreboard	Regional Innovation Index	2014	PDF
European Commission	Regional Innovation Scoreboard	Regional Innovation Index	2012	PDF
European Commission	Innovation Union Scoreboard	Summary Innovation Index	2007	PDF
European Commission	Innovation Union Scoreboard	Summary Innovation Index	2008	PDF
European Commission	Innovation Union Scoreboard	Summary Innovation Index	2009	PDF
European Commission	Innovation Union Scoreboard	Summary Innovation Index	2010	PDF
European Commission	Innovation Union Scoreboard	Summary Innovation Index	2011	PDF
European Commission	Innovation Union Scoreboard	Summary Innovation Index	2012	PDF
European Commission	Innovation Union Scoreboard	Summary Innovation Index	2013	PDF
European Commission	Innovation Union Scoreboard	Summary Innovation Index	2014	PDF
European Commission	Innovation Union Scoreboard	Summary Innovation Index	2015	HTML
European Commission	eGovernment Report	—	2014	HTML
European Commission	—	DESI	2015	HTML
European Commission	Benchmarking Deployment of eHealth among General Pra	—	2013	HTML
Between	—	Smart City Index	2014	PDF
Freedom House	Freedom In The World	Freedom on the net	2017	HTML
Freedom House	Freedom In The World	Freedom on the net	2015	PDF
ONU	E-Government Survey		2014	PDF
Boston Consulting Group	Which Wheels to Grease (update)	eFriction Index	2015	HTML
Boston Consulting Group	Greasing The Wheels Of The Internet Economy	eFriction Index	2014	PDF
Health Consumer Powerhouse	—	Euro Health Consumer Index	2014	HTML
Bloomberg	The Bloomberg Innovation Index	The Bloomberg Innovation Index	2016	HTML
World Justice Project	—	Open Government Index	2015	PDF
World Wide Web Foundation	—	Open Data Barometer	2015	HTML
Open Knowledge International	—	Global Open Data Index	2015	HTML
Future Brand	—	Country Brand Index	2015	PDF
ITU	—	Global Cybersecurity Index	2016	HTML
ITU	—	Global Cybersecurity Index	2014	PDF
UN	UN E-Government Survey 2016	E–Government Development Index	2016	HTML
UN	UN E-Government Survey 2017	E–Participation Index	2016	HTML
Istat CNEL	BES	Propensione alla brevettazione	2015	HTML
OECD	—	Better Life Index	2016	HTML
Numbeo	—	Quality of Life Index	2017	HTML
Roland Berger	THE RISE OF THE SMART CITY	Smart City Strategy Index	2017	HTML
IESE Business School	IESE CITIES IN MOTION STRATEGIES	Cities in motion Index (CIMI)	2016	HTML
2ThinkNow		The Innovation Cities™ Index	2017	HTML
World Bank Group	World Development Indicators:		2016	HTML

Annex III: Additional Indicators

Index	Level	KPI	Years covered	Unit of Measure	Comments	To be added?	Why?
Doing Business	**0**	**Ease of doing business**	**2003 - 2017**	**rank**	**1-190 positions**	**No**	**Composite Index**
Doing Business	0	DTF Score for Ease of doing business	2003 - 2017	Score 0 - 100	0 represents the worst performance and	No	Index
Doing Business	1	Starting a business	2003 - 2017	rank or DTF score	sub category of the ease of doing busine		It is a point very relevant for
Doing Business	2	*Procedures*	2003 - 2017	Number			Start-ups. Further it is fair to
Doing Business	2	*Time*	2003 - 2017	days			assume that improvements in
Doing Business	2	*Cost*	2003 - 2017	(% of income per capita)		Perhaps	this category are due to digitization, for instance
Doing Business	2	*Minimum capital*	2003 - 2017	(% of income per capita)			digitizing the stepts ro register a business at public
Doing Business	1	Dealing with construction permits	2003 - 2017	rank or DTF score	sub category of the ease of doing busine	No	N/A
Doing Business	2	*Procedures*	2003 - 2017	Number		No	N/A
Doing Business	2	*Time*	2003 - 2017	days		No	N/A
Doing Business	2	*Cost*	2003 - 2017	(% of Warehouse value)		No	N/A
Doing Business	2	*Building quality control index*	2003 - 2017	(0–15)		No	N/A
Doing Business	1	Getting electricity	2003 - 2017	rank or DTF score	sub category of the ease of doing busine	No	N/A
Doing Business	2	*Procedures*	2003 - 2017	Number		No	N/A
Doing Business	2	*Time*	2003 - 2017	days		No	N/A
Doing Business	2	*Cost*	2003 - 2017	(% of income per capita)		No	N/A
Doing Business	2	*Reliability of supply and transparency of tariffs index*	2003 - 2017	(0-8)		No	N/A
Doing Business	1	Registering property	2003 - 2017	rank or DTF score	sub category of the ease of doing busine	No	N/A
Doing Business	2	*Procedures*	2003 - 2017	Number		No	N/A
Doing Business	2	*Time*	2003 - 2017	days		No	N/A
Doing Business	2	*Cost*	2003 - 2017	(% of property value)		No	N/A
Doing Business	2	*Quality of land administration index*	2003 - 2017	(0-30)		No	N/A
Doing Business	1	Getting credit	2003 - 2017	rank or DTF score	sub category of the ease of doing busine	No	Wellness
Doing Business	2	*Strength of legal rights index*	2003 - 2017	(0–12)		No	Wellness
Doing Business	2	*Depth of credit information index*	2003 - 2017	(0–8)		No	Wellness
Doing Business	2	*Credit bureau coverage*	2003 - 2017	(% of adults)		No	Wellness
Doing Business	2	*Credit registry coverage*	2003 - 2017	(% of adults)		No	Wellness
Doing Business	1	Protecting minority investors	2003 - 2017	rank or DTF score	sub category of the ease of doing busine	No	N/A
Doing Business	2	*Extent of disclosure index*	2003 - 2017	(0–10)		No	N/A
Doing Business	2	*Extent of director liability index*	2003 - 2017	(0–10)		No	N/A
Doing Business	2	*Ease of shareholder suits index*	2003 - 2017	(0–10)		No	N/A
Doing Business	2	*Extent of shareholder rights index*	2003 - 2017	(0–10)		No	N/A
Doing Business	2	*Extent of ownership and control index*	2003 - 2017	(0–10)		No	N/A
Doing Business	2	*Extent of corporate transparency index*	2003 - 2017	(0–10)		No	N/A
Doing Business	1	Paying taxes	2003 - 2017	rank or DTF score	sub category of the ease of doing busine	No	Wellness
Doing Business	2	*Payments*	2003 - 2017	(number per year)		No	Wellness
Doing Business	2	*Time*	2003 - 2017	(hours per year)		No	Wellness
Doing Business	2	*Total tax rate*	2003 - 2017	(% of profit)		No	Wellness
Doing Business	2	*Postfiling index*	2003 - 2017	(0-100)		No	Wellness
Doing Business	1	Trading across borders	2003 - 2017	rank or DTF score	sub category of the ease of doing busine	No	Wellness
Doing Business	2	Time to export	2003 - 2017		sub category of Trading across borders	No	Wellness
Doing Business	3	*Documentary compliance*	2003 - 2017	(hours)		No	Wellness
Doing Business	3	*Border compliance*	2003 - 2017	(hours)		No	Wellness
Doing Business	2	Cost to export	2003 - 2017		sub category of Trading across borders	No	Wellness
Doing Business	3	*Documentary compliance*	2003 - 2017	$		No	Wellness
Doing Business	3	*Border compliance*	2003 - 2017	$		No	Wellness
Doing Business	2	Time to import	2003 - 2017		sub category of Trading across borders	No	Wellness
Doing Business	3	*Documentary compliance*	2003 - 2017	(hours)		No	Wellness
Doing Business	3	*Border compliance*	2003 - 2017	(hours)		No	Wellness
Doing Business	2	Cost to import	2003 - 2017		sub category of Trading across borders	No	Wellness
Doing Business	3	*Documentary compliance*	2003 - 2017	$		No	Wellness
Doing Business	3	*Border compliance*	2003 - 2017	$		No	Wellness
Doing Business	1	Enforcing contracts	2003 - 2017	rank or DTF score	sub category of the ease of doing busine	No	N/A
Doing Business	2	*Time*	2003 - 2017	days		No	N/A
Doing Business	2	*Cost*	2003 - 2017	(% of claim)		No	N/A
Doing Business	2	*Quality of judicial processes index*	2003 - 2017	(0-18)		No	N/A
Doing Business	1	Resolving insolvency	2003 - 2017	rank or DTF score	sub category of the ease of doing busine	No	N/A
Doing Business	1	Time	2003 - 2017	(years)		No	N/A
Doing Business	1	Cost	2003 - 2017	(% of estate)		No	N/A
Doing Business	1	Recovery rate	2003 - 2017	(cents on the dollar)		No	N/A
Doing Business	1	Strength of insolvency framework index	2003 - 2017	(0–16)		No	N/A
ICT Development Index	**0**	**IDI**	**2009 - 2017**	**Summing the weighted and normalized sub-indices in a total score or rank**	**Composite index that combines 11 indicators into one benchmark measure. It is used to monitor and compare developments in information and communication technology (ICT) between countries and over time.**	**No**	**Composite Index**
ICT Development Index	1	ICT Access	2009 - 2017	Summing the equally weighted values of the indicators included in the respective subgroup. Score between 1-10	Indicators included in this group provide an indication of the available ICT infrastructure and individuals' access to basic ICTs. Data for all these indicators are collected by ITU	No	Composite Index
ICT Development Index	2	*Fixed-telephone subscriptions per 100 inhabitants*	2009 - 2017	Number of subscriptions per 100 inhabitants		No	outdated
ICT Development Index	2	*Mobile-cellular telephone subscriptions per 100 inhabitants*	2009 - 2017	Number of subscriptions per 100 inhabitants	For the respective sub indice score (ICT access), values will be normalized and after normalizing the data, the individual series were all rescaled to identical ranges, from 1 to 10	No	Already covered
ICT Development Index	2	*International Internet bandwidth per Internet user*	2009 - 2017	Bit/s		No	Already covered
ICT Development Index	2	*Percentage of households with a computer*	2009 - 2017	Percent		Yes	Currently we just consider the PC skills of individuals, not the fact whether they are using a PC
ICT Development Index	2	*Percentage of households with Internet access*	2009 - 2017	Percent		No	Already covered
ICT Development Index	1	ICT use	2009 - 2017	Summing the equally weighted values of the indicators included in the respective subgroup. Score between 1-10	The indicators included in this group capture ICT intensity and usage. Data for all these indicators are collected by ITU	No	Composite Index
ICT Development Index	2	*Percentage of individuals using the Internet*	2009 - 2017	Percent		No	Already covered
ICT Development Index	2	*Fixed-broadband Internet subscriptions per 100 inhabitants*	2009 - 2017	Number of subscriptions per 100 inhabitants	For the respective sub indice score (ICT use), values will be normalized and after normalizing the data, the individual series were all rescaled to identical ranges, from 1 to 10	No	Already covered
ICT Development Index	2	*Active mobile-broadband subscriptions per 100 inhabitants*	2009 - 2017	Number of subscriptions per 100 inhabitants		No	Already covered
ICT Development Index	1	ICT skills	2009 - 2017	Summing the equally weighted values of the indicators included in the respective subgroup. Score between 1-10	Data on mean years of schooling rates and gross secondary and tertiary enrolment ratios are collected by the UNESCO Institute for Statistics (UIS).	No	Composite Index
ICT Development Index	2	*Mean years of schooling*	2009 - 2017	Number of years	For the respective sub indice score (ICT use), values will be normalized and	No	Wellness

ICT Development Index	2	*Secondary gross enrolment ratio*	2009 - 2017	Percent	use), values will be normalized and after normalizing the data, the individual series were all rescaled to identical ranges, from 1 to 10	No	Wellness
ICT Development Index	2	*Tertiary gross enrolment ratio*	2009 - 2017	Percent		No	Wellness
Freedom on the Net	**0**	**Freedom on the Net score**	**2011 - 2016**	**Score 0 - 100**	**A combined score of 0-30=Free, 31-60=Partly Free, 61-100=Not Free.** Details infrastructural and economic barriers to access, legal and ownership	**Perhaps**	**Only an unlimited and unbiased access to the internet allows a country to eduate its citizen comprehensively and so,**
Freedom on the Net	1	Obstacles to Access	2011 - 2016	0-25 points	control over internet service providers ,	No	
Freedom on the Net	2	*To what extent do infrastructural limitations restrict access to the internet and other iCTs?*	2011 - 2016	(0-6 points)		No	
Freedom on the Net	2	*Is access to the internet and other iCTs prohibi- tively expensive or beyond the reach of certain seg- ments of the population?*	2011 - 2016	(0-3 points)		No	
Freedom on the Net	2	*Does the government impose restrictions on iCT connectivity and access to particular social media and communication apps permanently or during speci c events?*	2011 - 2016	(0-6 points)		No	
Freedom on the Net	2	*Are there legal, regulatory, or economic obstacles that prevent the existence of diverse business enti- ties providing access to digital technologies?*	2011 - 2016	(0-6 points)		No	
Freedom on the Net	2	*To what extent do national regulatory bodies over- seeing digital technology operate in a free, fair, and independent manner?*	2011 - 2016	(0-4 points)		No	
Freedom on the Net	1	Limits on Content	2011 - 2016	0-35 points	Analyzes legal regulations on content, technical filtering and blocking of websites, self-censorship, the vibrancy and diversity of online news media, and	No	
Freedom on the Net	2	*To what extent does the state or other actors block or lter internet and other iCT content, particularly on political and social issues?*	2011 - 2016	(0-6 points)		No	
Freedom on the Net	2	*To what extent does the state employ legal, administrative, or other means to force deletion of particular content, including requiring private access providers to do so?*	2011 - 2016	(0-4 points)		No	
Freedom on the Net	2	*To what extent are restrictions on internet and iCT content transparent, proportional to the stated aims, and accompanied by an independent appeals process?*	2011 - 2016	(0-4 points)		No	
Freedom on the Net	2	*Do online journalists, commentators, and ordinary users practice self-censorship?*	2011 - 2016	(0-4 points)		No	
Freedom on the Net	2	*To what extent is the content of online sources of information determined or manipulated by the govern- ment or a particular partisan interest?*	2011 - 2016	(0-4 points)		No	
Freedom on the Net	2	*Are there economic constraints that negatively im- pact users' ability to publish content online or online media outlets' ability to remain nancially sustain- able?*	2011 - 2016	(0-3 points)		No	
Freedom on the Net	2	*To what extent are sources of information that are robust and re ect a diversity of viewpoints readily available to citizens, despite government e orts to limit access to certain content?*	2011 - 2016	(0-4 points)		No	
Freedom on the Net	2	*To what extent have individuals successfully used the internet and other iCTs as sources of information and tools for mobilization, particularly regarding political and social issues? To what extent are such mobilization tools available without government restriction?*	2011 - 2016	(0-6 points)		No	
Freedom on the Net	1	Violations of User Rights	2011 - 2016	0-40 points	Tackles surveillance, privacy, and repercussions for online speech and activities, such as imprisonment,	No	
Freedom on the Net	2	*To what extent does the constitution or other laws contain provisions designed to protect freedom of expression, including on the internet, and are they enforced?*	2011 - 2016	(0-6 points)		No	
Freedom on the Net	2	*Are there laws which call for criminal penalties or civil liability for online and iCT activities? (0-4 points)*	2011 - 2016	(0-4 points)		No	
Freedom on the Net	2	*Are individuals detained, prosecuted or sanc- tioned by law enforcement agencies for disseminat- ing or accessing information on the internet or via other iCTs, particularly on political and social issues?*	2011 - 2016	(0-6 points)		No	
Freedom on the Net	2	*Does the government place restrictions on anony- mous communication or require user registration?*	2011 - 2016	(0-4 points)		No	
Freedom on the Net	2	*To what extent is there state surveillance of internet and iCT activities without judicial or other independent oversight, including systematic retention of user traffic*	2011 - 2016	(0-6 points)		No	
Freedom on the Net	2	*To what extent are providers of access to digital technologies required to aid the government in monitoring the communications of their users?*	2011 - 2016	(0-6 points)		No	
Freedom on the Net	2	*Are bloggers, other iCT users, websites, or their property subject to extralegal intimidation or physi- cal violence by state authorities or any other actor?*	2011 - 2016	(0-5 points)		No	
Freedom on the Net	2	*Are websites, governmental and private enti- ties, iCT users, or service providers subject to widespread "technical violence," including cyberat- tacks, hacking, and other malicious threats?*	2011 - 2016	(0-3 points)		No	
BCG	**0**	**The BCG e-Friction Index**	**2015**	**eFriction value (0-100, while 0 is best)**	**https://www.bcgperspectives.com/Imag**	**No**	**Composite Index**
BCG	1	Infrastructure	2015		https://www.bcgperspectives.com/content/articles/digital_economy_telecommunications_greasing_wheels_internet		
BCG	2	ACCES	2015		Sub category of Infrastructure		
BCG	3	*Internet bandwith per capita (ITU)*	2015	Bit/s	The ITU framwork is already used above	No	see left
BCG	3	*International Internet bandwith per capita (Tele Geopgrapl*	2015	Bit/s	TeleGeography's Global Internet Geography is the world's most comprehensive source of data and analysis about international Internet capacity, traffic, service providers, ASN connectivity, and pricing.	No	already covered through DAS
BCG	3	*Consumer broadband penetration (Pyramid Research)*	2017	%	Pyramid research is a private research	No	already covered through DAS
BCG	3	*Business fixed-broadband penetration (Pyramid Research)*	2017	%	Pyramid research is a private research	No	already covered through DAS
BCG	3	*Mobile Internet subscription penetration (Ovum)*	2015	%	Ovum is a market-leading research and consulting business focused on helping digital service providers and their	No	already covered through DAS
BCG	3	*Number of IPv4 registrations per capita (BCP potaroo)*	daily	%	IPv4 adresses are almost exhausted and it is expected that the need of IP Adresses will increase significantly	No	KPI used to be covered by DAS, but will not be updated
BCG	3	Number of IPv6 registrations per capita (BCP potaroo)	daily	%	because of IoT and similar trends. In	Yes	any longer.
BCG	2	SPEED	2015		Sub category of Infrastructure		
BCG	3	*Peak fixed broadband connection speed*	2015	Mbps		No	already covered through DAS
BCG	3	*Average fixed-broadband connection speed*	2015	Mbps		No	already covered through DAS
BCG	3	*Peak fixed mobile connection speed*	2015	Mbps		No	already covered through DAS
BCG	3	*Average fixed-mobile connection speed*	2015	Mbps		No	already covered through DAS
BCG	2	PRICE	2015		Sub category of Infrastructure		
BCG	3	*Fixed-broadband pricing*	2015	$ per month at ppp		No	already covered through DAS
BCG	3	*Mobile pricing*	2015	$ per minute local call		No	already covered through DAS
BCG	2	TRAFFIC	2015		Sub category of Infrastructure		
BCG	3	*Traffic volumes per capita*	2015	Mbps		No	not relevant

BCG	3	*International traffic volumes per capita*	2015	Mbps		No	not relevant
BCG	2	ARCHITECTURE	2015		Sub category of Infrastructure		
BCG	3	*Exchange points per capita*	2015	Number		No	not relevant
BCG	3	*Number of networks per capita*	2015	Number		No	not relevant
BCG	3	*Content registered to ccTLD hosted onshore*	2015	%		No	not relevant
BCG	3	*Existence of independent regulato*	2015	0-1		No	not relevant
BCG	1	Industry	2015				
BCG	2	INFRASTRUCTURE	2015		Sub category of Industry		
BCG	3	*Quality of transport infrastructure for physical fulfilment*	2015	(0–7)		No	not related to digitization
BCG	3	*Quality of electricity and telephony infrastructure*	2015	(0–7)		No	not related to digitization
BCG	2	LABOR	2015		Sub category of Industry		
BCG	3	*ICT skills*	2016	(1-10)		No	already covered through DAS
BCG	3	*Quality of math and science education*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Availability of qualified engineers*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Capacity for innovation*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	2	LABOR	2016		Sub category of Industry		
BCG	3	*Financial-market sophistication*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Financing through local equity market*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Ease of access to loans*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Foreign direct-investment-to-GDP ratio*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Venture capital availability*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	2	ECONOMY	2016		Sub category of Industry		
BCG	3	*Strength of intellectual property protection*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Burden of customs procedures*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Prevalence of trade barriers*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Number of days to set up a business*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	1	Individual	2015				
BCG	2	ABILITY	2015		Sub category of Individual		
BCG	3	*Quality of education system*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Adult literacy rate*	2016	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*ICT skills*	2016	(1-10)		No	already covered through DAS
BCG	2	ACCESS	2015		Sub category of Individual		
BCG	3	*Internet users*	2015	%		No	already covered through DAS
BCG	2	BANKING	2015		Sub category of Individual		
BCG	3	*Availability of financial services*	2015	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Affordability of financial services*	2015	(0-7)	Global Competitiveness Index	No	Index is checked by Pietro
BCG	3	*Market penetration of bank accounts*	2015	%	Global Competitiveness Index	No	Index is checked by Pietro
BCG	1	Information	2015				
BCG	2	SITES	2015		Sub category of Information		
BCG	3	*Number of domains registered to each ccTLD per capita*	2015	Number		No	not relevant
BCG	2	CONTENT	2015		Sub category of Information		
BCG	3	Number of online open-encyclopedia pages in home langua	Daily	Number		perhaps	
BCG	3	*Number of micromessages made in home language*	Daily	Number		No	not relevant
BCG	3	*Share of population using social networks*		2015 %		No	already covered through DAS
BCG	2	DATA		2015	Sub category of Information		
BCG	3	*Commitment to open data*		2015 (0-1)		No	not relevant
BCG	2	OBJECTIVITY		2015	Sub category of Information		
BCG	3	*Press Freedom Index*		2015 (0-100)		No	covered through freedom hous
BCG	3	*Freedom on the Net score*		2015 (0-100)		No	covered above
BCG	2	OBSTACLES		2015	Sub category of Information	No	Last update 2013
BCG	3	*Filtering score*		2015 (1-15)			
WJP	**0**	**Open Government Index**	2015	**Average of four subcategories, value is within (0-1), while 1 ist best.**	**Is a measure of the openness of government. the WJP Open Government Index draws from general population and expert surveys**	**No**	**Wellness Index**
WJP	1	1 Publicized laws and government data	2015	0-1	Avg. Of 1.1 & 1.2		
WJP	2	1.1 Information in plain language and in all official language:	2015	0-1	Average of all subcategories	No	not related to digitization
WJP	3	*Could you please tell us how well or badly you think your local government is performing in the following procedures? Providing information in plain language about people's legal rights, so that everybody can understand them?*	2015	Very Well (1), Fairly Well (.667), Fairly Badly (.333), Very Badly (0)		No	Too specific
WJP	3	*In practice, the basic laws of [COUNTRY] are explained in plain language, so that people can understand them.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	3	*In practice, the local government provides easy-to-understand information on people's legal rights (criminal suspects' rights; workers' basic rights; public health issues).*	2015	Almost Always (1), In Most Cases (.667), In Some Cases (.333), Almost Never (0)		No	Too specific
WJP	3	*In practice, the basic laws of [COUNTRY] are available in all of cial languages*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	3	*The basic laws are publicly available in all of cial languages.*	2015	Almost Always (1), In Most Cases (.667), In Some Cases (.333), Almost Never (0)		No	Too specific
WJP	3	*In practice, the government strives to make the laws accessible in languages spoken by signi cant segments of the population, even if they are not "of cial" language.*	2015	Almost Always (1), In Most Cases (.667), In Some Cases (.333), Almost Never (0)		No	Too specific
WJP	2	1.2 Publicized laws and government data	2015	0-1	Average of all subcategories	No	not related to digitization
WJP	3	*Could you please tell us how well or badly you think your local government is performing in the following proce-dures? Providing citizens information about the govern-ment expenditures?*	2015	Very Well (1), Fairly Well (.667), Fairly Badly (.333), Very Badly (0)		No	Too specific
WJP	3	*How would you rate the information published by the government in print or on the web in terms of quality of the information?*	2015	Very good (1), Good (2), Bad (3), Very bad (4)		No	Too specific
WJP	3	*How would you rate the information published by the government in print or on the web in terms of quantity of the information?*	2015	Very good (1), Good (2), Bad (3), Very bad (4)		No	Too specific
WJP	3	*How would you rate the information published by the government in print or on the web in terms of accessibility of the information?*	2015	Very good (1), Good (2), Bad (3), Very bad (4)		No	Too specific
WJP	3	*How would you rate the information published by the government in print or on the web in terms of reliability of the information?*	2015	Very good (1), Good (2), Bad (3), Very bad (4)		No	Too specific
WJP	3	*How would you rate the information published by the government in print or on the web in terms of format of the information?*	2015	Very good (1), Good (2), Bad (3), Very bad (4)		No	Too specific
WJP	3	*In practice, national regulations are published on a timely basis (i.e. within the timelines mandated by the applicable law or regulation).*	2015	Almost Always (1), In Most Cases (.667), In Some Cases (.333), Almost Never (0)		No	Too specific

WJP	3	*In practice, administrative regulations can be obtained at little cost, such as by mail, or online.*	2015	Almost Always (1), In Most Cases (.667), In Some Cases (.333), Almost Never (0)		No	Too specific
WJP	3	*In practice, judicial decisions of the highest court are published on a timely basis.*	2015	Almost Always (1), In Most Cases (.667), In Some Cases (.333), Almost Never (0)		No	Too specific
WJP	3	*In practice, drafts of legislation (bills) to be discussed in the legislative body are made available to the public on a timely basis.*	2015	Almost Always (1), In Most Cases (.667), In Some Cases (.333), Almost Never (0)		No	Too specific
WJP	3	*In practice, legislative proceedings (e.g. bills submitted or presented before the legislature for consideration or approval) are broadcast to the public by radio or TV.*	2015	Almost Always (1), In Most Cases (.667), In Some Cases (.333), Almost Never (0)		No	Too specific
WJP	1	2 Right to Information	2015	(0-1)	AVERAGE (2.1, 2.2, 2.3, 2.4, 2.5, 2.6)	No	not related to digitization
WJP	3	2.1 Awareness of right to information	2015	(0-1)	Average of all subcategories	No	not related to digitization
WJP	3	*Are you aware of any laws that are intended to provide individuals with the right to access information held by government agencies?*	2015	Yes (1), No (0)		No	Too specific
WJP	3	*Have you not requested information from a government agency because you did not know you can ask the government for information?*	2015	Yes (1), No (0)		No	Too specific
WJP	3	2.2 Information requests - responsiveness	2015		Average of all subcategories	No	not related to digitization
WJP	3	*Did you receive the information from the official or government agency from which you requested it?*	2015	Yes (1), No (0)		No	Too specific
WJP	3	*Were you satisfied with the reasons given for not granting the information that you requested?*	2015	Yes (1), No (0)		No	Too specific
WJP	3	*How satisfied were you with the process of requesting the information?*	2015	Very satisfied (1), satisfied (.667), dissatisfied (.333), very dissatisfied (0)		No	Too specific
WJP	3	*Have you not requested information from a government agency because you didn't think the government would give it to you?*	2015	Yes (1), No (0)		No	Too specific
WJP	3	*If you could request to have access to information held by a government agency, how likely do you think it is that the agency will grant it, assuming the information is both public and properly requested?*	2015	Very Likely (1), Likely (.667), Unlikely (.333), Very Unlikely (0)		No	Too specific
WJP	3	*If the residents request a copy of the project design documentation prior to the initiation of the construction project, how likely are the relevant government authorities to provide them with such a copy?*	2015	Very Likely (1), Likely (.667), Unlikely (.333), Very Unlikely (0)		No	Too specific
WJP	3	*Assume that you request to have access to information held by the Ministry of Education about how the budget of that agency is spent. How likely is it that the government agency in charge will grant such information, assuming it is properly requested?*	2015	Very Likely (1), Likely (.667), Unlikely (.333), Very Unlikely (0)		No	Too specific
WJP	1	2.3 Information requests - quality	2015	(0-1)	Average of all subcategories	No	not related to digitization
WJP	3	*In terms of the specifics of the information you requested, would you describe the information that was supplied to you as being:*	2015	Pertinent and Complete (1), Incomplete (.667), Vague/unclear (.333), evasive/doubtful (0)		No	Too specific
WJP	3	*Assume that you request to have access to information held by the Ministry of Education about how the budget of that agency is spent. How likely is it that the information provided is pertinent and complete?*	2015	Very Likely (1), Likely (.667), Unlikely (.333), Very Unlikely (0)		No	Too specific
WJP	1	2.4 Information requests - timeliness	2015	(0-1)	Average of all subcategories	No	not related to digitization
WJP	3	*Approximately how long did it take to obtain the information that you requested?*	2015	Less than a week (1), between one week and one month (.75), between one month and three months (.5), between three months and six months (.25), more than six months (0)		No	Too specific
WJP	3	*Assume that you request to have access to information held by the Ministry of Education about how the budget of that agency is spent. How likely is it that the government agency will grant such information within a reasonable time period?*	2015	Very Likely (1), Likely (.667), Unlikely (.333), Very Unlikely (0)		No	Too specific
WJP	0	2.5 Information requests - affordability and trust	2015		Average of all subcategories	No	not related to digitization
WJP	3	*If you had to pay a fee to the official to obtain the information, what was the amount of that fee?*	2015	Open response		No	Too specific
WJP	3	*Did you have to pay a bribe (or money above that required by law) in order to obtain the information?*	2015	Yes (1), No (0)		No	Too specific
WJP	3	*Have you not requested information from a government agency because you don't trust the government as a source for this type of information?*	2015	Yes (1), No (0)		No	Too specific
WJP	3	*Assume that you request to have access to information held by the Ministry of Education about how the budget of that agency is spent. How likely is it that the government agency will grant such information at a reasonable cost?*	2015	Very Likely (1), Likely (.667), Unlikely (.333), Very Unlikely (0)		No	Too specific
WJP	3	*Assume that you request to have access to information held by the Ministry of Education about how the budget of that agency is spent. How likely is it that the government agency will grant such information without having to pay a bribe?*	2015	Very Likely (1), Likely (.667), Unlikely (.333), Very Unlikely (0)		No	Too specific
WJP	0	2.6 Information requests - general accessibility of information	2015	(0-1)	Average of all subcategories	No	not related to digitization
WJP	3	*How accessible are budget figures of government agencies in your country?*	2015	Very accessible (1), slightly accessible (.5), not accessible at all (0)		No	Too specific
WJP	3	*How accessible are copies of government contracts in your country?*	2015	Very accessible (1), slightly accessible (.5), not accessible at all (0)		No	Too specific
WJP	3	*How accessible are sources of campaign financing of elected officials and legislators in your country?*	2015	Very accessible (1), slightly accessible (.5), not accessible at all (0)		No	Too specific
WJP	3	*How accessible are disclosure records of senior government officials in your country?*	2015	Very accessible (1), slightly accessible (.5), not accessible at all (0)		No	Too specific
WJP	3	*How accessible are reports of the national human rights institution in your country?*	2015	Very accessible (1), slightly accessible (.5), not accessible at all (0)		No	Too specific

WJP	3	*How accessible are copies of administrative decisions made by national government agencies in your country?*	2015	Very accessible (1), slightly accessible (.5), not accessible at all (0)		No	Too specific
WJP	3	*How accessible are copies of adminsitrative decisions made by local government agencies in your country?*	2015	Very accessible (1), slightly accessible (.5), not accessible at all (0)		No	Too specific
WJP	3	*How accessible are transcripts of adminstrative proceedings in your country?*	2015	Very accessible (1), slightly accessible (.5), not accessible at all (0)		No	Too specific
WJP	0	3 Civic participation	2015	(0-1)	AVERAGE (3.1, 3.2, 3.3)	No	not related to digitization
WJP	2	3.1 Freedom of opinion and expression is effectively guaranteed	2015	(0-1)	Average of all subcategories	No	covered through freedom
WJP	3	3.1 A People are free to express politial opinions alone or in peaceful association with others	2015	(0-1)	Average of all subcategories	No	covered through freedom
WJP	4	*How likely is a citizen to be beaten by the police, without justification, for participating in a non-violent public demonstration in [COUNTRY]?*	2015	Very Likely (0), Likely (.333), Unlikely (.667), Very Unlikely (1)		No	Too specific
WJP	4	*In practice, people in [COUNTRY] can freely hold public non-violent demonstrations without fear of reprisal.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In [COUNTRY], people can freely express opinions against the government.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	3	3.1 B Freedom of the media is respected	2015	(0-1)	Average of all subcategories	No	covered through freedom
WJP	4	*In practice, the media (TV, radio, newspapers) in [COUNTRY] can freely expose cases of corruption by high-ranking government officers without fear of retaliation.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In practice, the media (TV, radio, newspapers) in [COUNTRY] can freely express opinions against government policies without fear of retaliation.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*How likely is a journalist to be attacked by the police, without justification, for covering a non-violent public demonstration in [COUNTRY]?*	2015	Very Likely (0), Likely (.333), Unlikely (.667), Very Unlikely (1)		No	Too specific
WJP	4	*How likely is the newspaper reporter to be threatened, imprisoned, or punished (either through official or unofficial means), either by the police or by the organized criminal organization?*	2015	Very Likely (0), Likely (.333), Unlikely (.667), Very Unlikely (1)		No	Too specific
WJP	4	*In practice in [COUNTRY], the government does not prevent citizens from accessing content published online.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In [COUNTRY], the media (TV, radio, newspapers) can freely expose cases of corruption by high-ranking government officers without fear of retaliation.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In [COUNTRY], the media (TV, radio, newspapers) can freely express opinions against government policies and actions without fear of retaliation.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	3	3.1 C Freedom of civil and political organization is respected (NGOs and political parties)	2015	(0-1)	Average of all subcategories	No	covered through freedom
WJP	4	*In practice, civil society organizations in [COUNTRY] can freely express opinions against government policies and actions without fear of retaliation.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In [COUNTRY], civil society organizations can freely express opinions against government policies and actions without fear of retaliation.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In [COUNTRY], political parties can freely express opinions against government policies and actions without fear of retaliation*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In practice in [COUNTRY], opposition parties can freely express opinions against government policies without fear of retaliation.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In practice, opposing factions within the dominant party can freely express opinions in public without fear of facing substantial negative consequences.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	2	3.2 Freedom of assembly and association is effectively guaranteed	2015	(0-1)	Average of all subcategories	No	covered through freedom
WJP	4	*In practice, civil society organizations in [COUNTRY] can freely express opinions against government policies and actions without fear of retaliation.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In practice, people in [COUNTRY] can freely join together with others to draw attention to an issue or sign a petition.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In practice, people can freely join any political organization they want.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In practice, people in [COUNTRY] can freely hold public nonviolent demonstrations without fear of reprisal.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In [COUNTRY], people can freely attend community meetings.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In [COUNTRY], people can freely join together with others to draw attention to an issue or sign a petition.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In [COUNTRY], people can freely join any (unforbidden) political organization they want.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	2	3.3 Right to petition and civic engagement	2015	(0-1)	Average of all subcategories	No	covered through freedom
WJP	4	*In practice, people in this neighborhood can get together with others and present their concerns to members of Congress.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific

WJP	4	*In practice, people in this neighborhood can get together with others and present their concerns to local government officials.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*In [COUNTRY], people can freely join together with others to draw attention to an issue or sign a petition.*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	4	*When talking to people about their local government, we often find important differences in how well local governments perform their duties. Could you please tell us how well or badly you think your local government (Metropolitan, Municipal, or District administration) is performing in the following procedures? Responding to people's concerns about community matters.*	2015	Very Well (1), Fairly Well (.667), Fairly Badly (.333), Very Badly (0)		No	Too specific
WJP	4	*When talking to people about their local government, we often find important differences in how well local governments perform their duties. Could you please tell us how well or badly you think your local government (Metropolitan, Municipal, or District administration) is performing in the following procedures? Consulting traditional, civil, and community leaders before making decisions.*	2015	Very Well (1), Fairly Well (.667), Fairly Badly (.333), Very Badly (0)		No	Too specific
WJP	4	*Now, here is a list of actions that people sometimes do. For each of these, please tell me whether you, personally, have done any of these things during the past 12 months? Attend a community meeting.*	2015	Yes (1), No (0)		No	Too specific
WJP	4	*In practice, how likely are local residents to receive sufficient advance notice of the impending construction project?*	2015	Very Likely (1), Likely (.667), Unlikely (.333), Very Unlikely (0)		No	Too specific
WJP	4	*In practice, if a large number of residents file an urgent petition proposing an alternative construction plan before the relevant administrative or judicial authority, how likely is the relevant administrative or judicial authority to suspend the project until the residents' alternative construction plan can be considered?*	2015	Very Likely (1), Likely (.667), Unlikely (.333), Very Unlikely (0)		No	Too specific
WJP	4	*In practice, people in [COUNTRY] can get together with others and present their concerns to local government officials*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	0	4 Complaint mechanisms	2015	(0-1)	Average of all subcategories	No	not related to digitization
WJP	1	*Could you please tell us how well or badly you think your local government is performing in providing effective ways to make complaints about public services?*	2015	Very Well (1), Fairly Well (.667), Fairly Badly (.333), Very Badly (0)		No	Too specific
WJP	1	*Could you please tell us how well or badly you think your local government is performing in providing effective ways to handle complaints against local government officials*	2015	Very Well (1), Fairly Well (.667), Fairly Badly (.333), Very Badly (0)		No	Too specific
WJP	1	*In practice, how likely are the residents to be given the opportunity to present their objections or comments to the relevant government authorities prior to the start of the construction project?*	2015	Very Likely (1), Likely (.667), Unlikely (.333), Very Unlikely (0)		No	Too specific
WJP	1	*To what extent do you agree with the following statements: By law, if a government agency denies a citizens' request for information, citizens have the right to challenge this decision before another government agency or a judge*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
WJP	1	*In practice, if a government agency denies a citizens' request for information, citizens can effectively challenge this decision before another government agency or a judge*	2015	Strongly Agree (1), Agree (.667), Disagree (.333), Strongly Disagree (0)		No	Too specific
ITU	0	**Global Cybersecurity Index**	**2014, 2016**	**Score 0 - 100**	**The Global Cybersecurity Index (GCI) is a composite index combining 24 indicators into one benchmark measure to monitor and compare the level of Member States' cybersecurity commitment. Based on Interviews and surveys the number of measures respective to each category are**	**Perhaps**	**DAS already has a security category that currently just focusses on individuals and enterprises. This index might add a country perspective**
ITU	1	1. Legal measures	2014, 2016	Sum of sub cat	Methodolgy	No	Too qualitative
ITU	2	1.1. Cybercriminal legislation	2014, 2016	Number	Questionnaire	No	Too qualitative
ITU	2	1.2. Cybersecurity regulation	2014, 2016	Number		No	Too qualitative
ITU	2	1.3. Cybersecurity training	2014, 2016	Number		No	Too qualitative
ITU	1	2. Technical measures	2014, 2016	Sum of sub cat		No	Too qualitative
ITU	2	2.1. National CERT/CIRT/CSIRT	2014, 2016	Number		No	Too qualitative
ITU	2	2.2. Government CERT/CIRT/CSIRT	2014, 2016	Number		No	Too qualitative
ITU	2	2.3. Sectoral CERT/CIRT/CSIRT	2014, 2016	Number		No	Too qualitative
ITU	2	2.4. Cybersecurity standards implementation framework for organ	2014, 2016	Number		No	Too qualitative
ITU	2	2.5. Cybersecurity standards and certification for professionals	2014, 2016	Number		No	Too qualitative
ITU	2	2.6. Child online protection	2014, 2016	Number		No	Too qualitative
ITU	1	3. Organizational measures	2014, 2016	Sum of sub cat		No	Too qualitative
ITU	2	3.1. Strategy	2014, 2016	Number		No	Too qualitative
ITU	2	3.2. Responsible agency	2014, 2016	Number		No	Too qualitative
ITU	2	3.3. Cybersecurity metrics	2014, 2016	Number		No	Too qualitative
ITU	1	4. Capacity building	2014, 2016	Sum of sub cat		No	Too qualitative
ITU	2	4.1. Standardization bodies	2014, 2016	Number		No	Too qualitative
ITU	2	4.2. Cybersecurity best practices	2014, 2016	Number		No	Too qualitative
ITU	2	4.3. Cybersecurity research and development programmes	2014, 2016	Number		No	Too qualitative
ITU	2	4.4. Public awareness campaigns	2014, 2016	Number		No	Too qualitative
ITU	2	4.5. Cybersecurity professional training courses	2014, 2016	Number		No	Too qualitative
ITU	2	4.6. National education programmes and academic curricula	2014, 2016	Number		No	Too qualitative
ITU	2	4.7. Incentive mechanisms	2014, 2016	Number		No	Too qualitative
ITU	2	4.8. Home-grown cybersecurity industry	2014, 2016	Number		No	Too qualitative
ITU	1	5. Cooperation	2014, 2016	Sum of sub cat		No	Too qualitative
ITU	2	5.1. Bilateral agreements	2014, 2016	Number		No	Too qualitative
ITU	2	5.2. Multilateral agreements	2014, 2016	Number		No	Too qualitative
ITU	2	5.3. International fora participation	2014, 2016	Number		No	Too qualitative
ITU	2	5.4. Public-private partnerships	2014, 2016	Number		No	Too qualitative
ITU	2	5.5. Interagency partnerships	2014, 2016	Number		No	Too qualitative
UN	0	**E Participation Index**	**2016**	**Normalized score between 0-1 (X - Xlow)/(Xhigh-Xlow)**	**A country's EPI reflects its e-participation mechanisms that are deployed by the government as compared to all other countries. The purpose of this measure is not to prescribe any particular practice, but rather to offer insight into how different countries are using online tools to promote interaction between citizen and government, as well as among citizens, for the benefit of all.**	**Perhaps**	**Highlights how much a country's citizen accepts online tools provided by the government. Interesting to compare e-gov with e-participation score**
UN	1	e-information	2016	points	provision of information on the Internet	No	Too qualitative
UN	1	e-consultation	2016	points	organizing public consultations online	No	Too qualitative
UN	1	e-decision-making	2016	points	involving citizens directly in decision pro	No	Too qualitative

Index	KPI	Years covered	Unit of Measure	Comments	To be added?	Why?	Our dashboard area
eGovernment development index	Government's online service index (UN)	Every 2 years	%	This is a sub-index, a part of the eGovernment development index (EGDI). Data were collected from a survey on national portal, e-services portal and e-participation portal, as well as the websites of the related ministries of education, labour, social services, health, finance and environment as applicable. Each question calls for a binary response. Every positive answer generates a new "more in depth question" inside and across the patterns. The outcome is an enhanced quantitative Survey with a wider range of point distributions reflecting differences in levels of e-government development among countries.	Maybe	Can give a different point of view about online services that is a weak area	PA - Results
eGovernment development index	Telecommunication Index	Every 2 years	%	Index reporting telecommunications aspects: bb, ubb, mobile ecc.	No	Already covered by DAS	
eGovernment development index	Human capital index: - Adult literacy - Gross enrolment ratio - Expected years of schooling - Mean years of schooling	Every 2 years	%	It's About skills and competences: - Adult literacy - Gross enrolment ratio - Expected years of schooling - Mean years of schooling	No	Absence of focus on digital skills	
eGovernment development index	ePartecipation index (UN)	Every 2 years	%	The survey have questions emphasizing quality in the connected presence stage of e-government. These questions focus on the use of the Internet to facilitate the provision of information by governments to citizens ('e-information sharing'), interaction with stakeholders ('e-consultation'), and engagement in decision-making processes ('e-decision making'). A country's E-Participation Index value reflects how useful these features are and the extent to which they have been deployed by the government compared with all other countries.	No	Already covered by DAS	
ICT Development Index	ICT access index: 1) Fixed telephone subscriptions per 100 inhabitants; (2) Mobile cellular telephone subscriptions per 100 inhabitants; (3) International Internet bandwidth(bit/s) per Internet user; (4) Percentage of households with a computer; (5) Percentage of households with Internet access	2007-2016	0-10 Points	The ICT access index is a composite index that weights five ICT indicators (20% each)	Maybe indicator (4) Percentage of households with a computer;		
ICT Development Index	ICT use index: (1) Percentage of Individuals using the Internet (2) Fixed-broadband subscriptions per 100 inhabitants (3) Active mobile-broadband subscriptions per 100 inhabitants	2007-2017	0-10 Points	DESI/DAS are more complete	No	Already covered by DAS	
World Bank, Enterprise Surveys	Firms offering formal training	2006-2015	% of firms	The percentage of firms offering formal training programs for their permanent, full-time employees.	Maybe	Can show one point discussed in the first WS, the effort of the firms and the importance given to specialized employed	
International Monetary Fund's Balance of Payments Manual	Telecommunications, computers, and information services imports	2009-2014	% of total trade	Telecommunications, computer and information services (% of total trade) according to the Extended Balance of Payments Services Classification EBOPS 2010, coded SI: Telecommunications, computer and information services.	No	Old data	
Eurostat, 'High technology' aggregations based on SITC Rev. 4	High-tech net imports	from 60's to 2016	% of total trade	High-technology imports minus reimports (% of total trade). The list of commodities contains technical products with a high intensity of R&D, based on the Eurostat classification, itself based on SITC Rev.4 and the Organisation for Economic Co-operation and Development (OECD) definition. Commodities belong to the following sectors: aerospace; computers & office machines; electronics, telecommunications; pharmacy; scientific instruments; electrical machinery; chemistry; nonelectrical machinery; and armament.	Maybe	We can extract just a fiew codes about some goods interesting like compute&office machines, telecommunications Below the links of datas and explanations of codes https://comtrade.un.org/da a/ http://ec.europa.eu/eurosta /cache/metadata/Annexes htec_esms_an5.pdf	
IHS Global Insight, Information and Communication Technology Database	Total computer software spending	2015	% of GDP	Computer software spending includes the total value of purchased or leased packaged software such as operating systems, database systems, programming tools, utilities, and applications. It excludes expenditures for internal software development and outsourced custom software development. The data are a combination of actual figures and estimates. Data are reported as a percentage of GDP.	No	Not enough data	
Global competitiveness Index	ICTs and business model creation	2015	value from 1 to 7	Average answer to the question: In your country, to what extent do ICTs enable new business models? [1 = not at all; 7 = to a great extent]	Maybe		
Global competitiveness Index	ICTs and organizational model creatio	2015	value from 1 to 7	Average answer to the question: In your country, to what extent do ICTs enable new organizational models (e.g., virtual teams, remote working, telecommuting) within companies? [1 = not at all; 7 = to a great extent]	Maybe		
Networked Readiness Index	Laws relating to ICTs	2014 - 2015	value from 1 to 7	How developed are your country's laws relating to the use of ICTs (e.g., e-commerce, digital signatures, consumer protection)? [1 = not developed at all; 7 = extremely well developed] |	Maybe	Interesting but qualitative values	
Networked Readiness Index	Availability of latest technologies	2014 - 2015	value from 1 to 7	In your country, to what extent are the latest technologies available? [1 = not at all; 7 = to a great extent]	Maybe		
Networked Readiness Index	Government procurement of advanced technology products	2014 - 2015	value from 1 to 7	In your country, to what extent do government purchasing decisions foster innovation? [1 = not at all; 7 = to a great extent]	Maybe		
Networked Readiness Index	Mobile network coverage rate	2014 - 2015	Percentage of total population covered by a mobile network signal	Percentage of inhabitants who are within range of a mobile cellular signal, irrespective of whether or not they are subscribers. This is calculated by dividing the number of inhabitants within range of a mobile cellular signal by the total population. Note that this is not the same as the mobile subscription density or penetration.	No	Already covered by DAS	
The World Bank, World Development Indicators	Secure Internet servers	2014 - 2015	Secure Internet servers per million population	Secure Internet servers are servers using encryption technology in Internet transactions.	Maybe	The reason of high/low number of transactions	
ITU World Telecommunication/IT Indicators Database 2015	International Internet bandwidth	2014	International Internet bandwidth (kb/s) per Internet user	The sum of the capacity of all Internet exchanges offering international bandwidth measured in kilobits per second (kb/s).	No	Old data	
ITU World Telecommunication/ ICT Indicators Database 2015	Fixed broadband Internet tariffs	2008-2015	(PPP $)	Monthly subscription charge for fixed (wired) broadband Internet service	No	Already covered by DAS	
World Economic Forum, Executive Opinion Survey	Quality of math and science education	2012 - 2015	value from 1 to 7	In your country, how do you assess the quality of math and science education [1 = extremely poor—among the worst in the world; 7 = excellent—among the best in the world]	Maybe	Qualitative, but can explain skills probems	

ITU World Telecommunication/ICT Indicators Database	Internet users	2010 - 2016	%	Percentage of individuals using the Internet	No	Already covered by DAS	
World Economic Forum, Executive Opinion Survey	Firm-level technology absorption	2013 - 2015	value from 1 to 7	In your country, to what extent do businesses adopt new technology?	Maybe	Usefull to measure innovation in firms	
World Economic Forum, Executive Opinion Survey	Capacity for innovation	2013 - 2015	value from 1 to 7	In your country, to what extent do companies have the capacity to innovate?	Maybe	Usefull to measure innovation in firms	
World Economic Forum, Executive Opinion Survey	ICT use for business-to-business transactions	2013 - 2015	value from 1 to 7	In your country, to what extent do businesses use ICTs for transactions with other businesses?	Yes	Investigate b2b transaction missing in desi	Firms - Results
World Economic Forum, Executive Opinion Survey	Business-to-consumer Internet use	2013 - 2015	value from 1 to 7	In your country, to what extent do businesses use the Internet for selling their goods and services to consumers?	No	Already measured in desi	
World Economic Forum, Executive Opinion Survey	Importance of ICTs to government vision of the future	2013 - 2015	value from 1 to 7	To what extent does the government have a clear implementation plan for utilizing ICTs to improve your country's overall competitiveness? [1 = not at all—there is no plan; 7 = to a great extent—there is a clear plan]	Yes	Measuring government vision, missing in desi	PA - enablers
World Economic Forum, Executive Opinion Survey	Government success in ICT promotion	2013 - 2015	value from 1 to 7	In your country, how successful is the government in promoting the use of ICTs? [1 = not successful at all; 7 = extremely successful]	Yes	Measuring government communication effort about ict	PA - enablers
World Economic Forum, Executive Opinion Survey	Impact of ICTs on access to basic services	2013 - 2015	value from 1 to 7	In your country, to what extent do information and communication technologies (ICTs) enable access for all individuals to basic services (e.g., health, education, financial services, etc.)?	Maybe		
World Economic Forum, Executive Opinion Survey	Internet access in schools	2013 - 2015	value from 1 to 7	In your country, to what extent is the Internet used in schools for learning purposes?	Yes	Missing in Desi/das, they measure only number of pc and number of schools having a website	Citizens - Enablers
World Economic Forum, Executive Opinion Survey	ICT use and government efficiency	2013 - 2015	value from 1 to 7	In your country, to what extent does the use of ICTs by the government improve the quality of government services to the population?	Yes	Usefull to measure results of PA efforts	PA - results
European Innovation Scoreboard	Enterprises providing ICT training	2010-2016	%	Share of enterprises providing training to develop/upgrade ICT skills of their personnel	No	Already covered by DAS	
European Innovation Scoreboard	Broadband penetration (enterprises)	2010-2016	%	Share of enterprises with a maximum contracted download speedof the fastest fixed internet connection of at least 100 Mbps	No	Already covered by DAS	
Open Data Barometer	Open Data Barometer	2013 - 2016	value out of 100	Availability and impact of open data	Yes	Better than indicator used by desi	PA - enablers
Euro Health Consumer Index	On-line booking of appointments	2012 - 2016	value from 1 (best) to 3 (worst)	Can patients book doctor appointments on-line?	Maybe	To be evaluated	
Euro Health Consumer Index	e-prescriptions	2013 - 2015	value from 1 (best) to 3 (worst)	Usage of e-prescription	Maybe	To be evaluated	
World Bank	Government effectiveness	1996 - 2015	From -2,5 to 2,5	Reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	Yes	Usefull to measure results of PA	PA - Results
Banca d'Italia - Monetary and financial indicators	Online banking users - families and firms	2009 - 2015	Number of families and firms	Number of online banking users	Maybe	Already covered, but this indicator split families and firms.	
Europen Central Bank	Transactions via telecommunication, digital or IT device	2015	Number of transactions	Number of transactions via telecommunication, digital o IT device	Yes	Focus on transactions not only on peole	
Europen Central Bank	E-money payment transactions with e-money issued by resident PSPs	2011 - 2015	Number of transactions	E-money payment transactions with e-money issued by resident PSPs	Maybe		
Global B2C eCommerce Report	eCommerce users	2016	Number and %	Number and % of eshoppers	No	Covered by DAS	
Global B2C eCommerce Report	eCommerce market value	2015 - 2016	Million euro	eCommerce national market value	Maybe		
Global B2C eCommerce Report	Enterprises selling online	2015 - 2016	Number and %	Enterprises selling online	No	Covered by DAS (change breakedown of desi consider only SMEs)	
WORLDWIDE RETAIL ECOMMERCE SALES	Digital Buyers	2014 - 2016	%	Digital buyers on internet users	No	Covered by DAS	
WORLDWIDE RETAIL ECOMMERCE SALES	Retail Ecommerce Sales	2014 - 2016	%	Retail Ecommerce Sales as a Percent of Total Retail	Maybe		

Annex IV: Panel Results STATA

```
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  log type:  smcl
 opened on:  10 Mar 2018, 20:57:09

1 . use "/Users/Pumaman5/Dropbox/Digital Maturity Index/Data/Panel Data(Time series)/Pa

2 . xtreg CA  IE_L1  FE_L1 CE_L1 PAE_L1 IA1_L1 IA2_L1 FA_L1 PAA_L1  cntrl_DoBss cntrl_R

Fixed-effects (within) regression               Number of obs      =        79
Group variable: country1                        Number of groups   =        26

R-sq:                                           Obs per group:
     within  = 0.8473                                         min =         1
     between = 0.5247                                         avg =       3.0
     overall = 0.4104                                         max =         4

                                                F(10,25)           =     90.21
corr(u_i, Xb)  = -0.8937                        Prob > F           =    0.0000

                              (Std. Err. adjusted for 26 clusters in country1)
------------------------------------------------------------------------------
             |               Robust
          CA |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       IE_L1 |   .0726336    .039588     1.83   0.078    -.0088995    .1541666
       FE_L1 |   .0142003   .0686007     0.21   0.838    -.1270855    .1554861
       CE_L1 |    .464473   .1586951     2.93   0.007     .1376343    .7913116
      PAE_L1 |   .1601055   .0707084     2.26   0.032     .0144789    .3057321
      IA1_L1 |  -.0450008   .0749159    -0.60   0.553    -.1992931    .1092914
      IA2_L1 |    .115095   .1086904     1.06   0.300    -.1087569     .338947
       FA_L1 |   .0911415   .1211098     0.75   0.459    -.1582889    .3405718
      PAA_L1 |  -.1593653   .0658621    -2.42   0.023    -.2950108   -.0237198
   cntrl_DoBss |    .034326   .0463811     0.74   0.466    -.0611976    .1298496
   cntrl_RuPop |  -1.57977   1.136524    -1.39   0.177    -3.920485    .7609456
       _cons |   .2900078   .1326224     2.19   0.038     .0168667    .5631488
-------------+----------------------------------------------------------------
     sigma_u |  1.5674168
     sigma_e |  .11087277
         rho |  .99502133   (fraction of variance due to u_i)
------------------------------------------------------------------------------

3 . use "/Users/Pumaman5/Dropbox/Digital Maturity Index/Data/Panel Data(Time series)/Pa

4 . xtreg IA IE_L1  FE_L1 CE_L1  PAA_L1 CA_L1 FA_L1  cntrl_DoBss cntrl_RuPop  ,fe robus

Fixed-effects (within) regression               Number of obs      =       104
Group variable: country1                        Number of groups   =        28

R-sq:                                           Obs per group:
     within  = 0.8865                                         min =         1
```

```
     between = 0.7763                                        avg =        3.7
     overall = 0.7309                                        max =          5

                                                  F(8,27)           =      95.39
corr(u_i, Xb)  = -0.9156                          Prob > F          =     0.0000

                                (Std. Err. adjusted for 28 clusters in country1)
------------------------------------------------------------------------------
             |               Robust
          IA |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       IE_L1 |   .1308212   .0607582     2.15   0.040     .0061556    .2554867
       FE_L1 |    .225785   .1102771     2.05   0.050     -.000485    .4520549
       CE_L1 |   .3119672   .3080458     1.01   0.320    -.3200906     .944025
      PAA_L1 |  -.1928795   .0711876    -2.71   0.012    -.3389443   -.0468147
       CA_L1 |   .4849337   .1173792     4.13   0.000     .2440915     .725776
       FA_L1 |   .2941114   .1570597     1.87   0.072    -.0281486    .6163714
  cntrl_DoBss |   .0331202   .1232192     0.27   0.790    -.2197047    .2859451
  cntrl_RuPop |  -.9743469   .5661235    -1.72   0.097    -2.135936    .1872427
        _cons |   .3820429   .0545972     7.00   0.000     .2700187    .4940671
-------------+----------------------------------------------------------------
     sigma_u |  1.2533809
     sigma_e |  .18671337
         rho |  .97829037   (fraction of variance due to u_i)
------------------------------------------------------------------------------

5 . use "/Users/Pumaman5/Dropbox/Digital Maturity Index/Data/Panel Data(Time series

6 . xtreg FA IE_L1  PAE_L1 FE_L1 CE_L1  PAA CA IA  cntrl_DoBss cntrl_RuPop  ,fe rob

Fixed-effects (within) regression               Number of obs     =        82
Group variable: country1                        Number of groups  =        25

R-sq:                                           Obs per group:
     within  = 0.6454                                         min =         1
     between = 0.0356                                         avg =       3.3
     overall = 0.0794                                         max =         4

                                                F(9,24)           =     11.31
corr(u_i, Xb)  = -0.4928                        Prob > F          =    0.0000

                                (Std. Err. adjusted for 25 clusters in country1)
------------------------------------------------------------------------------
             |               Robust
          FA |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       IE_L1 |  -.0130996   .0551363    -0.24   0.814    -.1268954    .1006962
      PAE_L1 |  -.0845818   .1104341    -0.77   0.451    -.3125066    .1433429
       FE_L1 |   .1609684   .0548995     2.93   0.007     .0476614    .2742754
       CE_L1 |   .3569654   .1989065     1.79   0.085    -.0535576    .7674883
         PAA |   .2990937   .1335449     2.24   0.035     .0234705    .5747168
          CA |  -.0243912   .1402974    -0.17   0.863    -.3139509    .2651685
```

IA	.1384131	.1165645	1.19	0.247	-.1021642	.3789904
cntrl_DoBss	-.0823667	.074893	-1.10	0.282	-.2369382	.0722048
cntrl_RuPop	1.020973	1.449235	0.70	0.488	-1.970101	4.012046
_cons	.0365401	.1958631	0.19	0.854	-.3677016	.4407817
sigma_u	1.1670372					
sigma_e	.13221139					
rho	.98732844	(fraction of variance due to u_i)				

```
7 . use "/Users/Pumaman5/Dropbox/Digital Maturity Index/Data/Panel Data(Time series)/Pa

8 . xtreg PAA CE_L1 FE_L1 IE1_L1 IE2_L1 PAE_L1 cntrl_DoBss cntrl_RuPop, fe robust

Fixed-effects (within) regression               Number of obs      =        60
Group variable: country1                        Number of groups   =        23

R-sq:                                           Obs per group:
     within  = 0.1049                                         min =         2
     between = 0.1296                                         avg =       2.6
     overall = 0.1463                                         max =         3

                                                F(7,22)            =      1.29
corr(u_i, Xb)  = -0.9237                        Prob > F           =    0.3016

                                (Std. Err. adjusted for 23 clusters in country1)
```

PAA	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
CE_L1	-.4057714	.4267209	-0.95	0.352	-1.290736	.4791936
FE_L1	-.2419946	.3852347	-0.63	0.536	-1.040922	.5569332
IE1_L1	.1045529	.1674437	0.62	0.539	-.2427041	.45181
IE2_L1	-.0491709	.2041451	-0.24	0.812	-.4725419	.3742002
PAE_L1	-.1899241	.3595487	-0.53	0.603	-.9355824	.5557341
cntrl_DoBss	-.0762877	.2454495	-0.31	0.759	-.5853189	.4327435
cntrl_RuPop	-2.860773	1.680222	-1.70	0.103	-6.34534	.6237939
_cons	-.1321091	.0765057	-1.73	0.098	-.2907721	.026554
sigma_u	2.4601922					
sigma_e	.29457894					
rho	.98586542	(fraction of variance due to u_i)				

```
9 . log close
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Annex V: Complete Panel Data results

Panel data	Countries	24	26	26	26	21	26
	Sample	76	79	79	83	68	100
	Model ID	1	2	3	4	5	6
	Model type	Fixed Effect	Fixed Effect	Random Effect	Fixed Effect	Fixed Effect	Fixed Effect
	Data Set	2011-2015	2011-2015	2011-2015	2011-2015	2011-2015	2011-2016
Dependent variable	Citizen A	Citizen A	Citizen A	Infstr A (Only IA2: BB takeup)	Infstr A (Only IA1 BB speed)	Infstr A (Only A3 Mobile)	Firm A
Independent variable	Citizen E	NA	NA	NA	NA	NA	NA
	Firm E	NA	NA	NA	NA	NA	NA
	Public admin E	NA	NA	NA	NA	NA	NA
	Infstr E	NA	NA	NA	NA	NA	NA
	Citizen E (previous Year)	***	***			**	
	Firm E (previous Year)			*		*	
	Public admin E (previous Year)		**	***	**		NA
	Infstr E (previous Year)		*		***		
	Citizen A	NA	NA	NA		NA	NA
	Firm A	**	NA	NA		NA	NA
	Public admin A		NA	NA		NA	NA
	Infstr A	*** (only IA2)	NA	NA		NA	NA
	Citizen A (previous Year)	NA	NA	***		**	
	Firm A (previous Year)	NA					NA
	Public admin A (previous Year)	NA	**				
	Infstr A (previous Year)	NA	only IA2 included	NA	NA	NA	
	Cntrl_var Doing Business				***(negative effect)		
	Cntrl_Var Rural Pop						

Panel data	Countries	28	25	25	27	25	27	23
	Sample	104	80	82	84	82	91	60
	Model ID	7	8	9	10	11	12	13
	Model type	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect
	Data Set	2011-2016	2012-2016	2012-2016	2012-2016	2012-2016	2010-2014	2010-2013
Dependent variable	Citizen A	Infstr A	Firm A	Firm A	Infstr A	Infstr A	Firm A	Public admin A
Independent variable	Citizen E	NA	NA	NA	NA	NA	NA	NA
	Firm E	NA	NA	NA	NA	NA	NA	NA
	Public admin E	NA	NA	NA	NA	NA	NA	NA
	Infstr E	NA	NA	NA	NA	NA	NA	NA
	Citizen E (previous Year)			*			*	
	Firm E (previous Year)	*	**	***	***			
	Public admin E (previous Year)	NA						
	Infstr E (previous Year)	**				*		
	Citizen A	NA			NA	**	NA	NA
	Firm A	NA		NA	NA		NA	NA
	Public admin A	NA		**	NA		NA	NA
	Infstr A	NA			NA	NA	NA	NA
	Citizen A (previous Year)	***		NA		NA	NA	NA
	Firm A (previous Year)		NA	NA		NA	NA	NA
	Public admin A (previous Year)	**		NA	*	NA	NA	NA
	Infstr A (previous Year)	NA		NA	NA	NA	NA	NA
	Cntrl_var Doing Business	*(negative effect)						
	Cntrl_Var Rural Pop							

Legend				
Not included in the model	Included but not significant	P-value < 0.1	P-value < 0.05	P-value < 0.01
NA		*	**	***