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Network Readiness and Internet Usage in the European Union

Bachelor thesis

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Abstract

This thesis focuses on the analysis of key drivers of broadband internet take-up and usage in the European Union. In particular, we explore the coverage effect on fixed-to-mobile broadband substitution and the consequent impact of computer skills and education parameters on e-services usage. These fields have undergone rapid transformation within the EU digital economy in recent years, especially due to the introduction of faster 'next generation' broadband networks and development of web applications. The research question investigates decisions of households with regards to broadband adoption as well as the impact of education and digital skills on the use of e-services. Our qualitative analysis examines differences in performance across EU member states considering key indicators set by the Digital Agenda for Europe 2020 policy objectives. We then apply empirical methods using panel data to test our two research questions. Our findings suggest that there is a significant effect of network coverage on the fixed-to-mobile broadband substitution and we confirm the relevance of computer skills on the increased usage of e-services in the EU.

Keywords

Digital agenda, broadband coverage, fixed-to-mobile broadband substitution, digital literacy, internet use, e-commerce, e-government.

Range of thesis: 127 941 symbols

Abstrakt

Tato bakalářská práce se zaměřuje na analýzu klíčových faktorů v oblasti zavádění a využívání širokopásmového internetu v Evropské unii. Zkoumáme zejména vliv pokrytí na substituci fixního připojení mobilním internetem a následný dopad počítačových dovedností a vzdělávacích parametrů na využívání elektronických služeb. V posledních letech prošly tyto oblasti digitální ekonomiky EU důležitými proměnami, a to zejména díky zavedení rychlejších sítí nové generace a rozvoji webových aplikací, což s sebou přineslo zásadní změny na trhu. Výzkumné otázky se zabývají rozhodováním domácností v oblasti širokopásmového připojení, jakožto i efektem vzdělávání a digitálních dovedností na používání e-služeb. Kvalitativní analýza se zaměřuje na rozdíly mezi členskými státy EU s ohledem na stěžejní ukazatele stanovené v cílech digitální agendy strategie Evropa 2020. Panelová data v empirické analýze nám slouží k zodpovězení dvou výzkumných otázek. Výsledky naznačují, že pokrytí má výrazný vliv na nahrazování širokopásmového kabelového připojení mobilním internetem a také potvrzují význam počítačových dovedností pro využití e-služeb v EU.

Klíčová slova

Digitální agenda, pokrytí širokopásmovým připojením, substituce fixního internetu mobilním, digitální gramotnost, využití internetu, e-komerce, e-government.

Declaration of Authorship

1. The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

2. The author hereby declares that all the sources and literature used have been properly cited.

3. The author hereby declares that the thesis has not been used to obtain a different or the same degree.

Prague 18th May 2017

Jakub Nikodym

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Bachelor Thesis Proposal

Author:	Jakub Nikodym
Supervisor:	Goran Serdarević PhD
Proposed Topic:	Network Readiness and Internet Usage in the European Union

Research Question and Motivation

The enormous growth of the internet in recent years has started to change the behaviour of most people in developed countries. Firms all over the world began implementing information technology in production processes and started collecting data to help them make better decisions. Their online sales of goods and services accounted for a substantial increment in the total output. Households with access to the internet also moved and accomplished many of their daily activities using electronic devices. Reading news, shopping, learning or searching for information are only glimpses of them. Even governments employed the internet into civil services to achieve transparent political actions and endorse participation of citizens. The information and communication technologies (ICT) bring not only productivity improvements, but also transform the way people communicate.

Despite the Digital Agenda 2020 policy is influencing all countries of the European Union, the approach towards information and communication technologies at the national level still differs widely. The key objective of this thesis is to examine the digital divide and main drivers, which have a major impact on adoption and extended use of the internet in European countries. We will also make an attempt to find out why some countries have lagged behind in the long term. Attention will be paid to the evolution of the use of e-services in particular countries as well. On that account two hypotheses are stated and will be examined in the thesis:

1) The technological progress (e.g. LTE, NGA coverage) influences the choice of broadband type in the European Union.

2) Countries with better education and digital skills are more inclined to use e-services.

Contribution

The bachelor thesis could bring a new perspective on a recent development of e-services in Europe. Since results will be predominantly derived from sources and datasets from the past few years, it is expected that the research will bring fresh insights and describe the changes that have taken place in the current digital economy. The quantitative and empirical analysis should uncover dissimilarities among the European population in adopting a stance on new technologies and point to the fact that some fields are worthy of more attention and investments.

Methodology

Empirical analysis will be predominantly performed at the national level using data obtained from the past years of development focusing primarily on adoption of broadband, and usage of e-services. In the models, we intend to compare the demand and supply sides in each field of activity to find out important indicators explaining the growth of e-services and their usage. From the supply side drivers, we will be investigating fixed and mobile broadband coverage, percentage of enterprises receiving orders electronically and government online availability. On the other hand, broadband internet tariffs, education, income level or computer and internet skills of individuals will represent demand side indicators.

The primary source of data will be extracted from the digital agenda by the European Commission and for the evaluation of countries' performance we will use the Global Information Technology Report presented by the World Economic Forum. Econometric models will be used to define causations and consequences of the recent development. Since the growth of the internet is an ongoing process, the panel data will provide a base for the research and enable us to track the evolution of the digital economy over time and across countries. The percentage of individuals using internet and e-services will be regressed on supply and demand as well as institutional and innovative indicators.

The quantitative analysis should highlight leading countries in which the use of e-services contributes significantly from a socio-economic perspective. To be more precise, the thesis will focus on economies where enterprises successfully use the internet to boost their businesses as well as individuals who use it to study, order goods and services, look for jobs or perform other activities online with positive spill-over effect. Eventually, Digital Agenda for Europe (a part of the Europe 2020 strategy) and national economic policies related to meaningful utilization of information and communication technologies

will be taken into consideration. Since, as is expected, insufficient attention to impacts of the internet could be a sticking point for some poorly engaged countries.

Outline

1. Introduction – A thorough presentation of the research question and its motivation.

2. Literature overview – A summary of recent studies on the given topic and related works.

3. Data and methodology – A specification of testing key hypotheses.

3.1. Approach – A description of empirical methods applied in the research.

3.2. Data– Properties and restrictions of the data are we relying on.

4. Quantitative analysis – Development outline of examined variables.

5. Empirical analysis – Findings, robustness and limitations of the research.

6. Conclusions – Implications of findings, their comparison to implemented policies and suggestions for a further useful research.

Core Bibliography

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List of Acronyms

DAE	The Digital Agenda for Europe
DESI	Digital Economy and Society Index
EC	European Commission
EU	European Union
ERDF	European Regional Development Fund
EAFRD	European Agricultural Fund for Rural Development
FE	fixed effects
HSPA	High-Speed Packet Access
ICT	Information and communication technologies
LTE	Long-Term Evolution
Mbps	Megabits per second
NGA	Next Generation Broadband Access
OECD	Organisation for Economic Co-operation and Development
OLS	ordinary least squares
RE	random effects
WEF	World Economic Forum

Contents

Introduction

The internet is nowadays known for its universal utilisation in nearly all areas of human life. In comparison to other mass media led by television, radio or newspapers, the internet is a relatively young invention with an enormous potential to replace all of its predecessors. Despite its extent, the internet has not fully exhausted its capability to grow. Global access to information and a network of devices make the internet able to assist decision making processes. The rising internet of things is only one example in which direction could lead to the development of only a half-century old system of interconnected networks.

In this thesis, a closer look will be taken on the availability of stable and fast infrastructure across countries as the fixed and mobile broadband are prerequisites for the use itself. It would be unwise to expect high beneficial internet use without an easily available connection. Since mobile technologies in households are slowly replacing desktops,[1] the fixed-to-mobile substitution will be one of the crucial topics of the thesis. The broadband coverage in urbanised and rural areas will serve to uncover decision making in households regarding internet connection.

The subsequent analysis will utilise findings from the broadband study and will characterise main drivers of e-commerce and e-government as representatives of a broader group of e-services. As education and digital literacy are critical points in the pursuit of EU smart growth, the regress models will be used to identify connections between countries human capital and effective employment of the internet.

The aim of this work is not only to provide an overview of digital performance on the country level. The European Commission already assembled, for this purpose, the Digital Economy and Society Index (DESI). (Bertschek & Ohnemus, 2016) By contrast, the author strives to study the changes in the digital market, and find the determinants that clarify network readiness and internet use.

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[1] Google Consumer Barometer (2016) (see Figure 4.1)

Motivation

After the start of the new millennium, fixed internet connection became cheaper than before and thus more affordable for all social classes in Europe. The smartphone boom accelerated the penetration of the internet but brought some dramatic changes to the broadband market. Mobile internet has gained high popularity and the increase in download speed made the mobile broadband not only the complement but also an equal substitute for the fixed type of connection in many countries.

The technological impact is also visible in products, services and the labour market. The unceasing digital development enhances alternatives to current business models. Easier barriers of entry have already kick-started the realisation of people ideas and modelled them into successful companies. The number of ICT specialists in EU increased by more than 1.5 million in the last five years,[2] which only covers a low proportion of professions requiring ICT knowledge of applicants.

The increasing web traffic and users' interactions generate an enormous amount of information. The contemporary popular start-ups built their business on the ownership of users' network and valuable personal data. Physical assets were suppressed by digital figures and intellectual property. A relatively new concept of big data finds utilisation in the private sector for marketing purposes as well as in the public activities leading to improvements in transport, health and education sectors - essential for the society. (Duhaneanu & Marin, 2014)

All economic aspects create motivation to examine the digital market, not only within the European Union but also on a global scale. Nevertheless, a high variability of socio-economic factors, as well as technological and political diversity of the world, would not allow studying the topic in more detail. The European Union shares the Digital Agenda for Europe presenting the common direction of ICT development and the concept of a sound digital single market strategy. This strategy allows a unique possibility to study the progress and compelling circumstances of recent steps in the EU member states.

Adopting a stance of governments in the European Union towards a digital economy is not as homogenous as it would appear. Since member countries descent from different economic and political backgrounds, their vision regarding the nearest digitisation and

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[2] Eurostat – Employed ICT specialists (2011 - 2016)

actions noticeably varies. Moreover, the digital progress is in many cases faster than legislative, executive and judicial branches of government. Therefore, prompt state intervention could avert adverse side effects or sway the direction of development and utilisation of the internet.

European Digital Slowdown

Despite the significant acceleration of ICT implementation and digital EU growth at the beginning of the new millennium, starting the financial crisis in 2008, the European e-commerce market lost its momentum and is lagging behind new digital leaders. According to the Digital Evolution Index formed by the Fletcher School at Tufts University, European countries were ranked in the "stall out" and "watch out" categories, lacking the needed power to start up innovations in the technological sector. (Chakravorti, Tunnard, & Chaturvedi, 2015) The widening gap between the competitiveness of the European Union and the United States or eastern economies is also one of the reasons why the European Commission introduced the digital single market as the essential pillar of the Europe 2020 Strategy. (European Commission, 2010b)

Ark and Bart (2015) claim credit for the decrease in European productivity not only to the cyclical factors but also for the low flexibility of the private sector in adopting new technologies. The situation is, however, typical not only for firms and enterprises. In the area of connectivity development, it is important whether the society can take advantage of faster broadband. Innovatory mode of households and individuals is critical for future development. The increase in usage of new technologies can enhance returns on investments and subsequent broadband implementation.

Concerning new technologies, the European Union can be termed as conservative compared to the rest of the world. The European society is more guarded than Asian countries. The industrial and technological revolutions came in Europe earlier, but were running late. The European Union has to also cope with the heterogeneity of members' economies. European institutions help to reduce the differences between the new members and well-performing countries in Northern and Western Europe though realised structural funds. Unfortunately, different regulations prevent the European institutions from running many unified programs effectively on the union level.

The online market helped reduce the importance of distance regarding information accessibility. The progress in the online world is better than offline, however high

transaction costs and inefficient delivery of services within the EU are still significant elements of the poorly performing digital single market.

The rigidity of Europe is caused mainly by different legal systems and behaviour of companies, which tend to perform their businesses on national rather than regional levels. In many cases, the businesses do not offer the possibility to deliver goods in all member States. Legislative obstacles make it much more complicated to provide services in the new market and keep the quality standards. From the perspective of a consumer, these obstacles decrease the variety of products and corresponding prices available and decrease the overall well-being. On the other hand, a level of e-government is much more dependent on intra-county activities. European governments are not in this case tied by excessive rules regarding the introduction of portals and provision of online services to citizens.

Background

Broadband Attributes

This work does not aim to describe technical details and specifications of the broadband; however, it is worth to present key terms and concepts behind the abbreviations used to get a better understanding of the following part of the thesis even for people not so oriented in the ICT branch. The author uses a distinction between two types of connection – mobile and fixed broadband. Definitions of networks are diverse and complex; thus the author provides the reader with those used in the study prepared for EC - Broadband Coverage in Europe 2015 – also the source of coverage data in this study.

In this work, the mobile broadband coverage will present technological standards of HSPA (High-Speed Packet Access) and LTE (Long-Term Evolution). HSPA represents an older and slower type of mobile connection which offers an upgraded version of 3G network enabling downloading at a maximum speed of 21.1 Mbps. LTE is an abbreviation of the next generation mobile network that supports internet connection speeds of up to 100 Mbps.

On the opposite side of the spectrum, fixed broadband tends to be described by maximum download speed limits which give users more precise information about the benefits. Thus, services can easily be compared by the general public. The dawn of the internet was accompanied by a network of copper cables with a maximum download speed of 24

Mbps. However, the subsequent discovery unlocked the advantage of optical fibres, which enabled an increase in data transfer rate. As described by the Broadband Glossary composed by the European Commission, NGA (Next Generation Access) built the network which was partly created from optical fibres. This technology enables a faster connection above the copper limit, 24+ Mbps in download speed, comparable to LTE networks. (Jackson, 2010) In the thesis, the author incorporated fixed rate categories using lower bounds of 2 (alternatively 10), 30 and 100 Mbps. The lowest speed class is used to provide a comparison to HSPA standards, while 30 and 100 Mbps, with labels as fast and ultra-fast broadband, reflect targets of Digital Agenda for Europe.

E-services Characteristics

The development of the internet created possibilities of its utilisation in a significant number of new sectors in world economies. The e-commerce, e-learning, e-business, e-government or online (mobile) banking represents a broad spectrum of interactions between providers and beneficiaries. According to the Oxford Dictionaries, the prefix "e" stands for "*electronic data transfer for information exchange and financial transactions via the Internet"*. E-services commonly function as alternatives to many traditional services in the real world and offer the possibility to execute actions with other users or institutions regardless of the place or time of connection. The term could be characterised as an interaction between users (meaning one-to-one, one-to-many, many-to-many or many-to-many) to achieve various purposes while using the ICT (mainly the internet). Among the most widespread e-services, belongs e-commerce and e-government. Since e-commerce represents private sector digital development and e-government reflects the integration of ICT by public authorities, these fields provide an exquisite possibility to examine countries' digital progress.

The history of electronic commerce dates back to the 1970s when the term was related to sending business documents, orders and invoices electronically. The concept of e-commerce, in the sense that people know it today, came on the scene only in 1998. Nowadays, after 19 years of evolution, this phenomenon includes a vast scope of business activities. E-commerce describes the execution of online transactions (purchase and sale) of goods and services, which could be delivered "offline", but also in digitised form. (Coppel, 2000) The highly embedded representation of e-commerce among the public

presents the B2C[3] type, where the customer is the end-user of products sold online. Despite this fact, a substantial amount (90%) of electronic commerce accounts for a B2B[4] type. (OECD, 2013) The e-commerce model could differ significantly based on the characteristic of both sides and e-commerce platform including instant purchases, auctions; subscriptions, physical or digitised products. E-procurement, mentioned above, represents the intersection of e-government with G2B[5] or B2G[6] fields of e-commerce. Due to the growth in wireless broadband in recent years, mobile commerce (m-commerce) noticed a sharp gain in popularity too. Mobile-friendly websites and native applications, enable users to order and pay using just a few clicks. The simplification of checkout processes and a reduction in the time required to place an order thus became crucial factors for successful m-commerce. (Sharma & Sharma, 2015)

Advantages of e-commerce are indisputable as this concept reduces the operational costs, which creates lesser barriers for new entrants and a consequent increase in the diversity of products and services available on the market. These are often cheaper than in brick-and-mortar stores. (OECD, 2013) The decrease in information asymmetry forestalls the adverse selection problems. The increasing competition in the market accelerates innovations in the e-commerce field. To deliver the best impression to buyers, sellers improve variety and simplicity of payment methods and also push the delivery time to the minimum. These aspects generate a positive spillover into banking and logistic industry.

The role of government in the digital economy does not incorporate only intervention and coordination of the external development. Countries should also make a contribution by developing their own digital applications. E-government primarily serves communication between government and citizens or businesses using electronic devices. Communication could include not only the delivery of information and services through internet but also the online participation of the public in decision-making (sometimes referred to e-participation). (World Bank, 2015) 24/7 online accessibility of e-government creates an efficient way of solving the excessive workload of authorities. It is also the factor that profoundly influences progress in the integration of electronic devices into day to day

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[3] business to customer

[4] business to business

[5] government to business

[6] business to government

processes. (Almarabeh & AbuAli, 2010) Online public services should be easily accessible through browsers of desktop, tablet or mobile, because technical barriers together with low digital literacy on both, supply and demand, sides limit e-government use. (Tinholt et al., 2015)

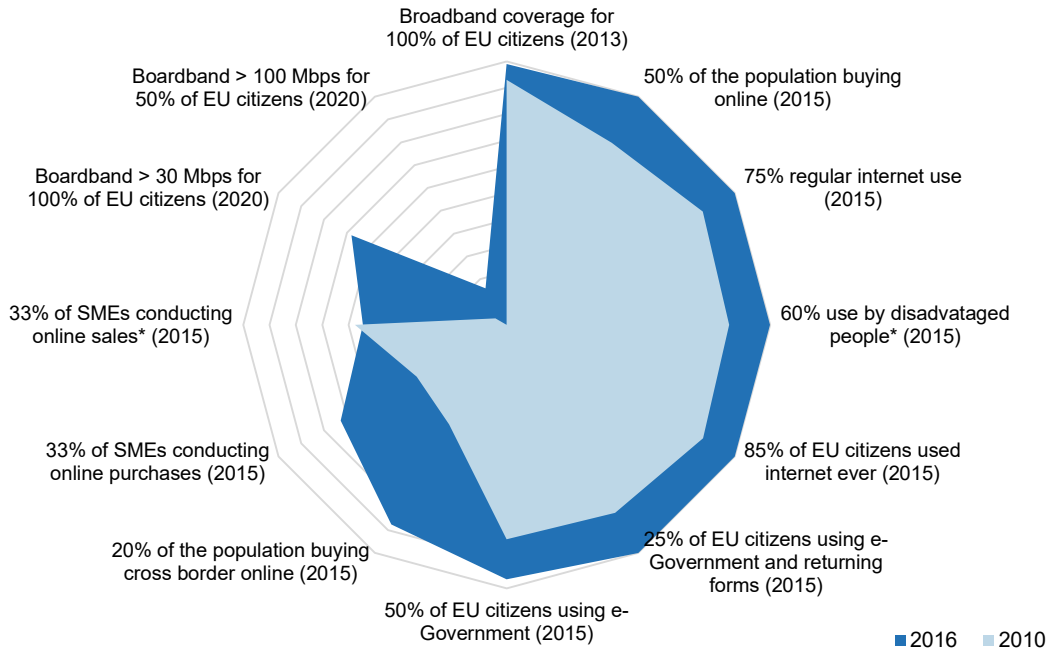
As a result of implementation in European countries, e-government causes a higher transparency of political actions as well as cuts in administrative costs. From the demand side perspective, the electronic government brings benefits to citizens and businesses through a reduction in bureaucratic burdens and acceleration of approval processes. The development of e-government has increased its pace in recent years. The most ambitious targets from the citizen's point of view include online application forms for passports, IDs and driving licences, and strengthening the democratic rights of citizens through active online participation in decision making. Businesses could, besides already mentioned services, take advantage of online tax payments and transparent environment for public procurement. (Palvia & Sharma, 2007)

Digital Agenda - Europe 2020 Strategy

Political steps towards research and development of the digital market have evolved through the years, and it takes some time for any program to gain enough power to become significant to European governments. The Digital Agenda for Europe is not the first application of this sort that the European Union gave a rise. ICT got into EU's sphere of interest for the first time in an Action Plan of the Information Society presented by the European Commission in 1994. Before the start of the new millennium, the development of the ICT sector was plentifully connected with gaining human capital and digital skills of the society. This era was followed by eEurope – An Information Society for All (1999), eEurope 2002 Strategy and eEurope 2005 Action Plan respectively reflecting the knowledge-based growth of the economy and the provision of a suitable environment for job creation and private investment. The path towards the Digital Agenda for Europe was continued through the i2010 Strategy presented in 2005. Even though the European Commission had already identified imbalances in network expansion and a low level of digital literacy, there was still a missing unified political framework. (Mansell, 2014) The Digital Agenda for Europe published in 2010 as a part of the Europe 2020 Strategy includes the commitment to undertake 101 politic actions (78 devoted to EC and 23 to member states), which should enhance the usage of digital technologies and stimulate investments in the ICT sector. (European Parliament, 2011)

DAE is thematically divided into seven pillars: i) A vibrant Digital Single Market, ii) Interoperability & Standards, iii) Trust & Security, iv) Fast and ultra-fast internet access, v) Research and innovation, vi) Enhancing digital literacy, skills, and inclusion, vii) ICT-enabled benefits for EU society, and one additional International dimension. (European Commission, 2010) Execution of DAE by the European Commission and member countries is what led to the smart growth – the European economy based on knowledge and innovation. (Mansell, 2014) The EC measures the targets and progresses made by countries in the Digital Scoreboard supplementing already mentioned Digital Economy and Society Index. Together with agendas, the EC created 13 targets reflecting the performance, which should be fulfilled mainly on the union level within the period from 2011 to 2015/2020. (European Parliament, 2011)

Figure 1.1: Selected targets of the Digital Agenda for Europe[7]



Source: Author based on Eurostat, European Commission – Digital Agenda Scoreboard (2010 and 2016)
* - used 2011values (instead of 2010 values)

The e-commerce inclusion into targets presents a slight complication for the European Union. In particular, the participation of the private sector on the cross-border dimension

[7] *Single Market for telecoms services, ICT R&D increase* and *Promotion of low energy lighting* targets are not included.

is below the desired level. The EU managed to fulfil the target of broadband coverage for all EU citizens, but adoption process of fast (> 30 Mbps) and ultra-fast (> 100 Mbps) broadband is still slow. Only a huge improvement in following years will allow fulfilling targets in 2020. There is also the question, whether selected targets reflect the right means to reduce the digital divide and maximise the impacts from a socio-economic perspective.

Despite the fact that the European Union has the necessary technology to manipulate the e-regulation, there are minimal incentives fostering unified legal framework. The law deficiency in the ICT sector brings uncertainty to entrepreneurs' actions. The Digital Agenda stresses the fast development of the digital economy. However, it is important to be aware that the pace of digital economy is seven times faster than the rest of the economy. (Kerikmäe & Dutt, 2014) On the grounds of this fact, the legal system often lags behind the rapid progress of ICT.

Research Questions

In the theoretical part, the author described a digital slowdown and development of policies related to ICT in the European Union. Research questions should help the reader understand the issues within the EU regarding the internet adoption and its meaningful use. The connectivity indicators and e-services are linked through the set of DAE targets. The penetration will be used to explain online activities as well. Because of the expectation that the same combination of incentives does not drive both dimensions, the author divided the research question into two parts and will examine adoption and usage parameters separately.

RQ1: Is the slow development of LTE, NGA and ultra-fast broadband in the country able to influence household’s choice of connection type (i.e. fixed vs. mobile broadband connection)?

RQ2: Are countries with superior education and digital skills more inclined to use e-services?

Literature Overview

Coverage, Speed and Price Effect on the Internet Penetration

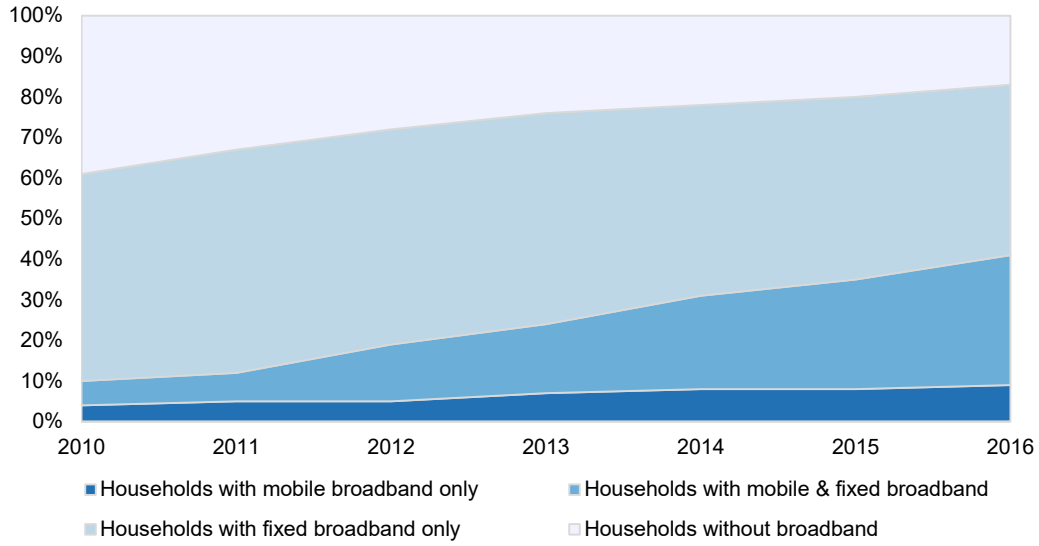
The coverage and speed of broadband connections belong to the mentioned targets of the Digital Agenda. These dimensions are also essential prerequisites to the penetration and

frequency of internet use. The coverage is closely linked to speed, as maximal transfer speeds are always determined by the specification of the cables, fibres and mobile networks. In addition to that, the coverage presents the precondition of the internet adoption in households and businesses. The unavailability of the service causes the citizens not to be able to connect to the internet at all. The connection with higher speed conversely enables citizens to access information and data without delays, therefore increasing the effectiveness of internet use.

The penetration of fixed broadband started to increase in the late 1990's as fibre improvements enabled the increase of download speeds and lower prices made the internet affordable to the general public. The acceleration of growth came hand in hand with smartphones and wireless connection. (Bauer & Latzer, 2016) The relatively young mobile broadband soon started to appear not only as the complementary service for the fixed broadband but also a successor as well.

At the dawn of the new millennium, Europe relieved the substitution between fixed telephone lines and mobile phones. On one hand, there was a group of individuals switching to cell phones as it was a direct substitute for them, on the other hand, there persists a more conservative group of adopters who tend to use mobiles as a complement to fixed lines. The substitute/complement adoption process accompanied many other technological developments. Grzybowski (2014) examined in his paper the substitution effect between the fixed and mobile broadband. He presented the negative correlation between the fixed/mobile prices ratio and "mobile only" households, which indicates the copper or fibre fixed-line broadband is an inferior good as long as price plays no role in people's decision. The changes in broadband connection types in the European Union between years 2010 and 2016 clearly depict the following stacked area graph.

Figure 2.1: Fixed-to-mobile broadband substitution (EU-28 average)



Source: Author based on Eurostat - Households - type of connection to the internet (2010 - 2016)

At the moment, when the fixed-to-mobile substitution is present, it is important to consider the prices of both types of connection in models. Although price plays a major role in decision making between types of broadband, the recent studies showed that the cost of internet connection would not encourage a majority of internet non-users to adopt broadband. (Levin, Schmidt, & Scott, 2016) According to Eurostat statistics, only 3 percent of EU-28 households in 2016 did not consider a broadband connection as the price of access was too high, and 4% mentioned expensive equipment as the main reason for no access. By contrast, the most common household's explanation (7%) is that broadband is not needed. Despite this fact, the monetary characteristics explain much variation in adopting the fixed and mobile broadband, an analysis of last years' data brings the apparent imbalance in the internet use even in countries within a similar income group. (Bauer & Latzer, 2016)

The pricing mechanism in the case of fixed connection has not changed much in the last years. Households pay for a connection having a certain speed but an unlimited amount of data downloaded. Conversely, operators commonly charge the mobile internet according to the data transferred and do not advertise the connection speed as a primary advantage. In a case of tariffs with small data limits, customers often reach the quota before the end of the invoicing period. If they wish to access the mobile internet onward at advertised speed, they are forced to renew the data tariffs. Unlimited mobile data tariffs

are still in infancy; thus the price of mobile connections is expected to be a more relevant determinant of penetration.

Cincera, Dewuldf and Estache (2015) studied the effect of speed on mobile broadband adoption in 18 European countries between 2008 and 2012. Authors included a dummy variable, indicating whether the country had developed LTE technology yet. They came to a conclusion that the increase of LTE coverage and download speed in mobile networks accelerates the mobile internet adoption and additionally doubles the fixed-to-mobile broadband substitution. Grzybowski & Verboven (2014) also showed, that the substitution effect is stronger in Central and Eastern Europe, where the fixed broadband quality is lower than in the rest of the continent.

The coverage gap is associated mainly with urban/rural heterogeneity. The rural areas suffer from lower coverage and deficit of superfast broadband connection. This fact can make these areas unable to compete on the national or even global level in business, public administration, education and many other branches. Less urbanised regions became, therefore, unattractive to young people for a living and the underdevelopment of broadband services can also reinforce social inequalities within the countries. (Townsend, Sathiaseelan, Fairhurst, & Wallace, 2013)

Besides from coverage, speed, and price, the most common factors explaining the adoption of the internet are age, level of education, digital skills, and GDP per capita or income level. (Amiri & Reif, 2013) (Townsend et al., 2013) (Cincera et al., 2015) (Schmidt, Levin, & Scott, 2015)

Digital Divide

Although the European Union strives to reach a digital single market with a widespread availability of internet connection, the heterogeneity in the use of the internet in the member states as well as across age and income groups persists. The differences are in the ICT sector commonly described by the expression "digital divide". OECD (2001) defines this term as *"the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access information and communication technologies (ICTs) and their use of the Internet for a wide variety of activities*."

Mobile broadband appears to bring possibilities that decrease the connectivity gap between countries and regions. The easy internet access through mobiles or laptops

should give European citizens possibilities to enhance education, digital literacy and knowledge oriented economy. The decrease in the cost of smartphones favours mobile broadband as well. The fast connection alone is not able to bring the same results across the whole of Europe.

A majority of authors investigated the digital divide among the EU-28 on the country level. However, it is not the only dimension where the differences are significant. Using a subsequent clustering, could uncover the variation between groups with low, mid and high education and bring an interesting view on the dispersion of education groups in particular countries. (Cruz-Jesus, Vicente, Bacao, & Oliveira, 2016) This study provides useful insights for identifying internal divides, where we can see the differences not only in ICT adoption but also in useful utilisation (e-learning, civic participation, and cross-border e-commerce). The education-related digital divide was also described by Pantea and Martens (2013) in their example of five largest EU economies. The positive effect of education was according to their study even stronger in the case of websites related to human capital, goods, and services. Authors furthermore presented the negative effect of income on time spent online. The significant drawback of this part is that in the eastern and southern part of Europe in comparison to the best performing European economies the penetration of ITC is lower and low-income person's behaviour could be different. Thus their outcomes could not be applied in the same manner on EU level. Moreover, the opposite dependency should not be assigned to the income but rather the fact that the usage of the internet could be, for wealthy people, an inferior leisure activity. (González Chapela, 2016)

An alternative method to examine the digital divide is by creating categories which describe the adoption and purpose of internet use. Based on online behaviour patterns, the EU-15 citizens can be separated into following segments Laggards, Confused and adverse, Advanced Users, Followers and Non-Internet Users. (Ortega Egea, Menéndez, & Román González, 2007) A similar division was presented in the paper "Understanding the new digital divide — a typology of Internet users in Europe", but with slightly adjusted categories: Sporadic Users, Instrumental Users, Entertainment Users, Advanced Users and Non-Users. (Brandtzæg, Heim, & Karahasanović, 2011) Population groups vary from study to study in naming, structure and also in count. There was an attempt to anchor groups in media-user typology, (Brandtzæg, 2010) however, no similar approach has been adopted by major institutions into their statistical reports yet.

It is critical to focus on the utilisation of internet by citizens, to understand the digital divide deeper in a European context. Table 2.1 provides the outline of 20 characteristic online activities and their frequency. Those connected with leisure and passive consumption of the content, rank in the upper part of the table. On the contrary, activities requiring complex interactions with websites and those related to an increase of human capital lag behind. Member states should prevent the inefficient use of ICT, raise public awareness and cope with the digital divide. Mainly because young people could be influenced by the pathological inefficient use of the internet. According to OECD (2001), countries should focus primarily on enhancing the quality of network infrastructure, catalysing the national or union projects, diffusion amongst individuals and business sectors and increasing ICT related skills of citizens. Nevertheless, even improvements in all stated policies do not certainly have to lead to meaningful use of the internet in European countries.

Table 2.1: Online activities by percentage of EU citizens

Online activity	**% of individuals**
Sending/receiving e-mails	71
Finding information about goods and services	66
Playing/downloading games, listening to music or watching videos	64
Reading online news sites/newspapers/news magazines	58
Participating in social networks	52
Internet banking	49
Seeking health information	48
Consulting wikis (to obtain knowledge on any subject) *	45
Travel and accommodation services	40
Looking for information about education, training or course offers *	32
Telephoning or video calls	32
Uploading self-created content to any website to be shared	28
Downloading software *	23
Selling goods or services	18
Any of the learning activities	18
Job search or sending an application *	17
Civic or political participation *	14
Posting opinions on civic or political issues via websites *	11
Doing an online course (of any subject)	6
Creating websites or blogs	5

Source: Eurostat - Internet use and activities (2016), * - values for 2015

Digital Skills and Education in Relation to E-services Usage

Works related to adoption and usage of e-services mushroomed due to the importance of online sectors to world economies in the last decade. Studying drivers of the e-services usage brings up some interesting findings. The majority of authors worked with obvious drivers e.g. fixed broadband penetration. Some of them also included debatable determinants in models e.g. education level. (Seri, Bianchi, & Matteucci, 2014) Advanced internet users regarding the usage of web services are, according to Ortega et al. (2007), employed men with tertiary education living in metropolitan areas, but Seri et al. inferred that higher education does not have to be necessarily associated with usage of all e-services. Their e-participation models showed a significant negative coefficient in the education parameter. In several models, even GDP per capita indicators transpire with the negative estimate. This fact presents a unique variation in internet adoption and e-services. According to Standard Eurobarometer, the highest frequency of use can be observed for students of which 97% use the internet on a daily basis.[8] Not surprisingly seniors are less prone to access the internet as well as low-income part of the European society.

Based on recent studies, the use of e-services seems to produce ambivalent results of the characteristics of users. While performing certain activities is positively associated with schooling or wages, in a case of selected e-services, these factors bring converse results. Dissimilarities are also visible in the e-commerce sector. Vicente (2015) covered in his work a brief analysis of heterogeneity among C2C e-commerce users by the employment of the EU-28 survey conducted in 2013. The empirical study demonstrates people selling online tend to be rather unemployed citizens with low education and income levels. On the contrary, buyers are more commonly employed individuals with secondary or tertiary education belonging to the high-income part of the population.

Although education provides the proper projection of country's human capital, for ICT related studies a level of digital skills is a more accurate indicator. The digital skills are critical in an era of computerising as they enhance the effectiveness of internet usage. Most of EU citizens still acquire these skills through learning by doing processes, and only a small portion of the population developed their skills through formal education.

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[8] EC - Standard Eurobarometer 86 (2016)

(Ţiţan, Burciu, Manea, & Ardelean, 2014) Digital skills are not only essential for the present beneficial internet use, but also for future occupations related to artificial intelligence, internet of things or any other branches in the computerised world. Nations with low digital literacy will not be able to play a competitive role in the market.

With regards to online behaviour, the term "digital skills" is more frequently replaced by "internet skills". Deursen and Dijk (2010) provided a division of Internet skills based on related online activities and abilities. They described four types of skills: (i) operational (measure web fluency and ability to handle the internet), (ii) formal (relate to the level of orientation between pages and understanding the structure of websites), (iii) information (describe the ability to classify search results, find desired information and involve critical thinking to evaluate findings) and (iv) strategic (cover the capacity to utilise the internet sources to accomplish more or less specific goals). The definition and order of these internet skills categories lay the foundation for understanding the efficient use of internet technology in the society. Deursen and Dijk (2016) extended their research and found out the influence of traditional education on internet skills. There is a weak relationship between operational skills and education level. Formal, information and strategic categories are, on the other way around, positively associated with the degree of traditional literacy. Moreover, individuals with higher strategic skills tend to use the internet frequently for information and career related activities. Information and strategic digital literacy enable users to study through e-learning platforms and educate themselves. This reinforcing paradox, therefore, further increases the knowledge-gap in society.

Qualitative Analysis

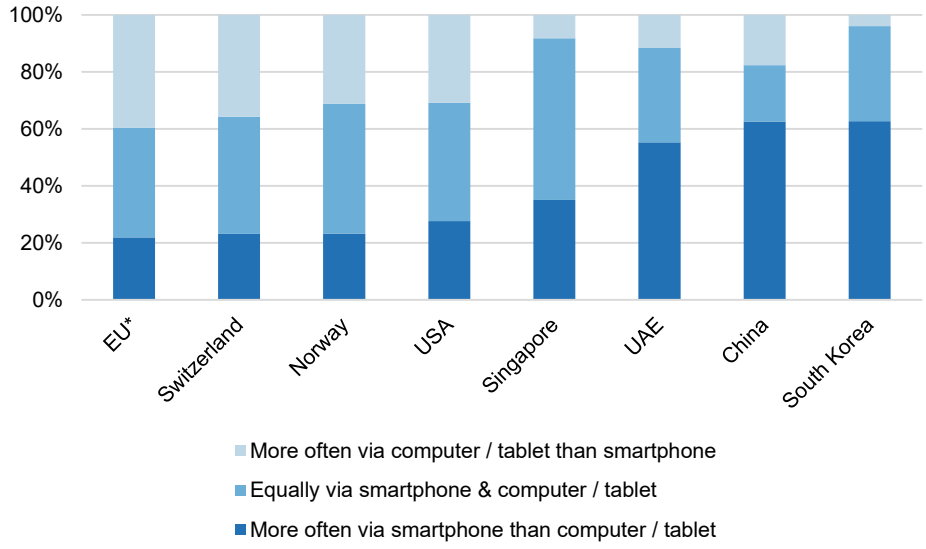
The qualitative analysis, which precedes the empirical one, uncovers the countries' positions on the digital market and presents some correlations of drivers and internet adoption. Starting with descriptive and inferential statistic readers will be familiarised with the current situation on the European market. For the purpose of regional division of EU-28 and comprehension of the differences on the continent, we used United Nations geo-scheme for Europe by UN Statistics Division (Appendix 1). This clustering method naturally has some drawbacks, and other sources can employ a different approach to the division of the continent. However, it is not within the scope of this work to find the best fitting segmentation.

The EU and Digital Leaders

In Europe, the epicentre of the industrial revolution, technology always has generous support. Despite this fact, the momentum of technological advancement in the last years is more or less unsatisfactory, and therefore the old continent started to lag behind world digital leaders. Not only does the governmental funding seem inefficient in member states, but also network operators in Europe invest only half of US' amount per household and still have struggles to gain higher returns on investments. The reduction of state control and entry of new competitors into the broadband and telecommunications market could facilitate the decrease of prices and enhance the efficiency of investments. (Downes, 2015)

The digital leaders accelerate faster than Europe depending on their ability to absorb. Eastern countries represented by United Arab Emirates, China or South Korea are leaders in the "mobile-first" world. The fixed to mobile broadband substitution is already in place there. South Korea was ranked in the first place in the ICT Development Index 2016 composed by the International Telecommunication Union.

Figure 4.1: With which connected devices do people most often go online?



Source: Author based Google consumer barometer - The Connected Consumer Survey (2016), *Cyprus, Malta and Luxembourg are not included

Even in Europe there are still states that digitally overcome the EU-28 leaders. Switzerland dominates the world with the outstanding business use of ICT, its capacity

for innovation is the highest worldwide.[9] Norway is the number one in the connectivity sphere and network readiness. 92% of Norwegians also use the internet on a daily basis[10], which is the highest number in Europe. Another non-member state Iceland is also performing reasonably, but the Arab countries and Southeast Asia are taking over the leadership in ICT sector and it is surely worth following these economies.

A similar pattern brings about the e-government situation. According to the Network Readiness Index 2016 composed by the World Economic Forum, the Arab countries and Southeast Asia dominate the World in the governmental use of information and communication technologies.

Intra-EU Geopolitical Differences in Investments and Progress of the Internet

A regional heterogeneity in the European Union deepened the digital divide further. Finances pumped into development and innovations through Structural and Cohesion Funds are not always spent efficiently. As Reggi and Scicchitano (2014) examined, monetary resources provided by European funds are very often invested based on previous regional programs, and as a result, some strategic aspects are underinvested. Chiefly less-developed regions waste financial resources in fields where they are already performing well. That is why floods of money would not bring the coveted impact as long as the return from the investments into new technologies will have a small return. (Ark & Bart, 2015)

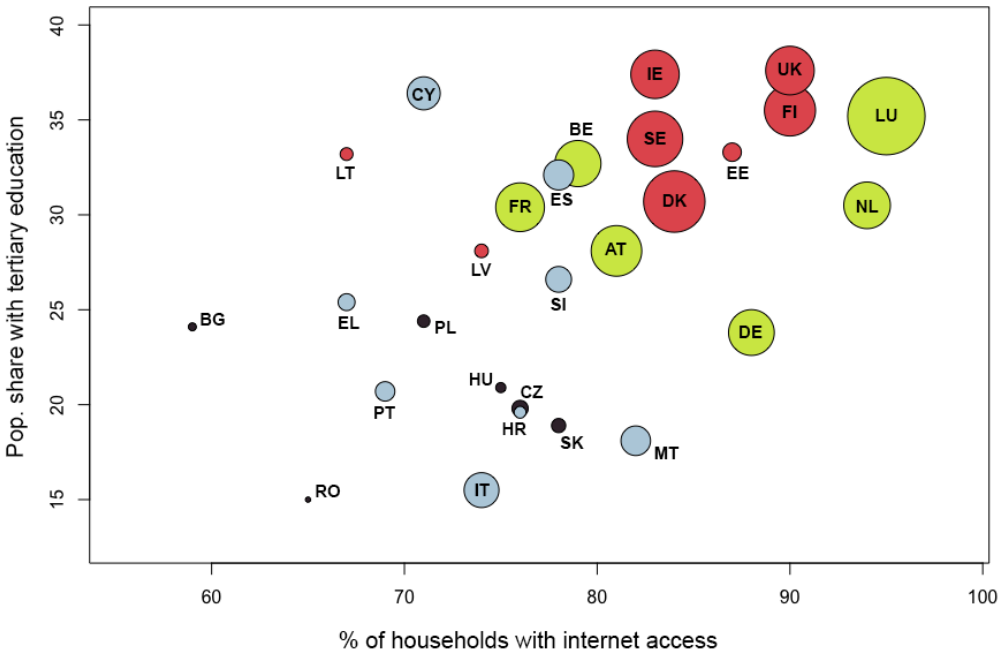
A brief differentiation based on the Eurostat data between post-communist countries and developed Europe was provided by Zoroja (2011). He focused mainly on the education and gender dissimilarities between 2005 and 2010. Since that time, the European market has rapidly changed, but the digital gap, caused partly by different power control, is still visible. The imbalance in mean income, characterising the research of the wealth of nations, (represented by the diameter of bubbles in Figure 4.2) is minor in the members developed under the Soviet power. The positive dependence of income and education on

[9] World Economic Forum - Network Readiness Index (2016)

[10] Eurostat - Individuals - frequency of internet use (2016)

penetration was already mentioned. The graphic illustration in Figure 4.2 allows the reader to better understand regional differences.

Figure 4.2: Broadband penetration based on education and mean income



Source: Author based on Eurostat - Households - type of connection to the internet, Mean and median income by household type, Population by educational attainment level, sex and age (2015)

The aim of the following section is to describe digital affairs in particular countries and regions and reveal their potential for growth in fields of internet penetration, e-commerce and e-government. In this paper, we also included some observations from European Structural and Investment Funds allocation, as they provide a substantial portion of financial resources invested in digital development.

Northern Europe

The internet usage in northern countries is commonly higher than in other parts of the continent. According to Google Consumer Barometer 2016, 87% percent of northerners used the internet for personal purposes, which was nine percent above the rest of Europe. These economies also lead in terms of the frequency of usage. 88% of the online population accesses the internet daily.[11] The dominant position confirms the WEF

[11] Eurostat - Individuals - frequency of internet use (2016)

Network Readiness Index 2016, in which all Nordic states are ranked among the top 40. They are rightfully called powerhouses of digitising in Europe.

The success of EU-28 leaders (Denmark, Sweden and Finland) is driven by citizens' digital skills and successful integration of e-services. Ambitions of their national broadband plans are placed above the mentioned DAE targets. Sweden, Finland and Denmark aim to reach 90%, 99% and 100% coverage of 100 Mbps service respectively by 2020. (European Commission, 2016) Governments in Nordic regions are conscious of the importance of broadband infrastructure in the economic development of their countries. It is the reason, why the penetration rate reaches Europe's maximum. (Amiri & Reif, 2013)

Finland is the first member state in which there is a highly visible fixed-to-mobile substitution. The homeland of Nokia, a former pioneer of mobile phones, is well versed in terms of mobile broadband in the EU. Broadband penetration in households in 2013 exceeded the presence of fixed broadband. Since that time, the popularity of mobile type connection rose to 85%.[12] In 2016, the average Finn owned a 1.47 SIM-card with active mobile broadband, which was by far the highest number in the European Union.[13]

The rest of Nordic countries follow the example of Finland in the mobile field, but each country has its own priorities in terms of digital strategy. Denmark laid the foundations of digitisation in the governmental sphere. The integration of citizens and businesses came in later stages, but in the moment when inherent difficulties were already resolved. This strategy enabled Danes to extend e-services into taxation, education, healthcare and many other fields in a relatively short period. Digital identification is no longer an issue of citizens only; the e-ID concept has penetrated to the business sector as well as the database of private properties. Taking advantage of data from a broad spectrum of industries reduced costs and boosted efficiency in governmental operations. (Igari, 2014) The earlier development of e-government strategies enables Nordics to orient their effort towards making e-services more user-friendly and beneficial to the society.

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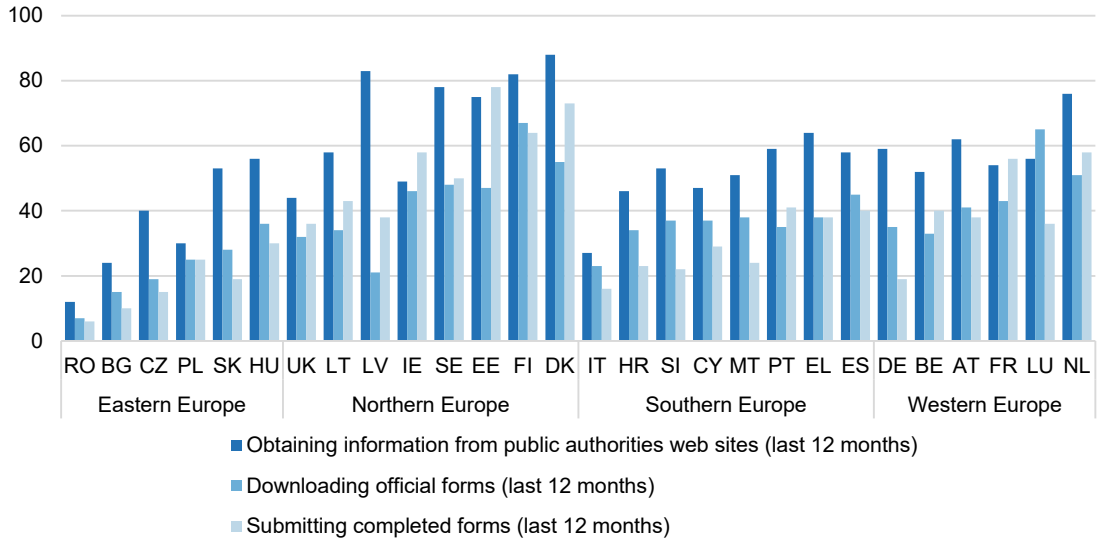
[12] Eurostat - Households - type of connection to the internet (2013 – 2016)

[13] Digital Agenda Scoreboard - Take-up of mobile broadband (2016)

Figure 4.3: E-government activities as share of internet users



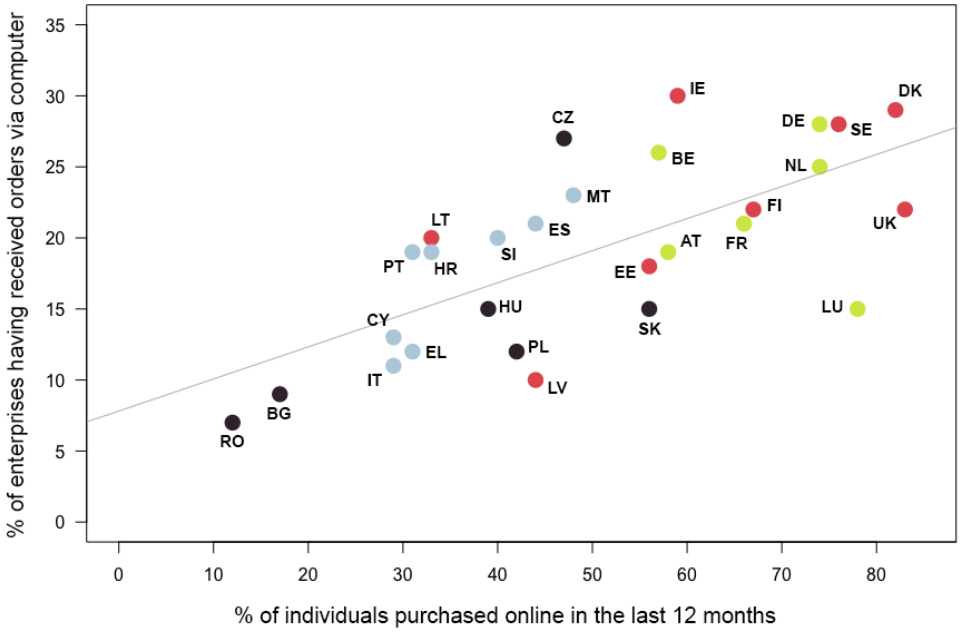
Source: Author based on Eurostat - Individuals using the internet for interaction with public authorities, by type of interaction (2016)

Danes dominate in obtaining information from public authorities online, but they are overtaken by their southern neighbours in submitting completed forms. Estonian concept represents another successful case of e-government implementation. This Baltic leader is placed quite high in rankings, chiefly due to the successful launch of digital public services. The small population helps Estonians to introduce e-ID infrastructure which facilitates electronic identification of citizens in any type of communication with public authorities, banks and other institutions. (Bendiek, Berlich, & Metzger, 2015) Estonia provides an excellent example of how a relatively small post-communist country could stand out in the "digital world" and compete with advanced Nordic economies.

Development of Ireland e-commerce and e-business presents an excellent model of private-sector growth. There are not many courtiers, where the penetration of ICT in business has influenced firms so intensively. Ireland is the leader in intra- and inter-country e-commerce among member states. The progress in these areas is driven by internal decisions and usefulness of the technology rather than pressures from the external environment. From the research, the internet adoption among small and medium enterprises (SME) enhanced their productivity, and online communication improved the image of the company. (Doherty, Ramsey, Harrigan, & Ibbotson, 2016) It is not surprising that Ireland (particularly Dublin) is the European base not only for SME, but also for

technology giants represented by Google, Facebook, Dropbox, LinkedIn and Airbnb as well.

Figure 4.4: E-commerce supply-demand correlations



Source: Author based on Eurostat - ICT usage in households and enterprises (2016)

The significant proportion of Ireland cross-border e-commerce travels to its neighbour and its most important trade partner, United Kingdom. Despite the fact, UK serves as one of the world's financial centres, its integration of information technology and digitisation of a private sector is not as smooth as that of Ireland. The investments in UK technology business quadrupled between 2011 and 2015 to £1.57 billion, but the desired effect is still insufficient. The UK government is aware of the potential impact and included the digitisation of the business sector into its Digital Strategy. (Department for Culture, Media & Sport, 2017) On the contrary, UK is the leader in a share of citizens, who purchased goods or services online. From the scatter plot shown in Figure 4.4 it can be easily inferred that the increasing trend in the rate of online shopping correlates with a growth in the supply (share of enterprises receiving orders online) among member states.

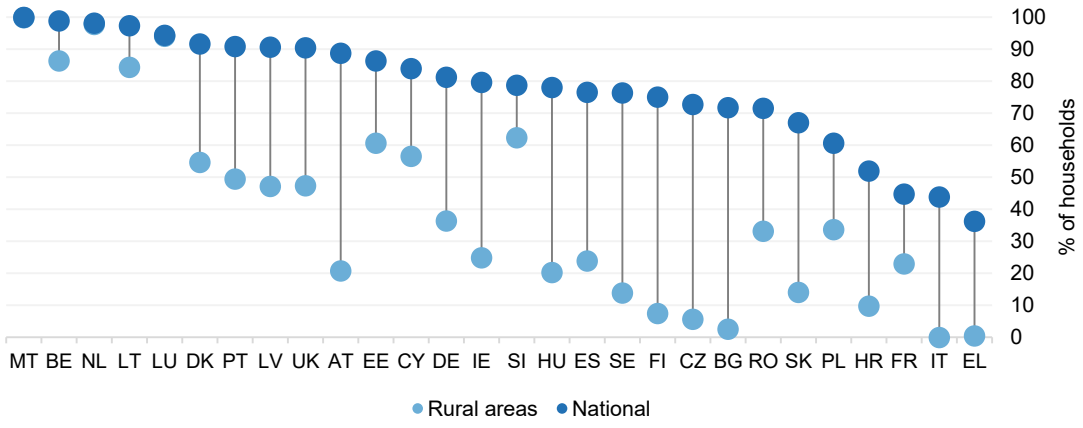
Northern countries have not rested on their laurels, but have further increased their digital inclusion. Their pioneering activities nowadays serve as an example of digitisation in public and private sectors.

Western Europe

Without doubt, the strong point of Western Europe is electronic commerce. In other studied subjects, it is still a very thriving region, but there are differences in comparison to Northern Europe. Benelux countries hold the dominant position in Western Europe. Their performance in the connectivity sphere ranks at the EU top. (see Figure 4.5)

Belgian, Luxembourg and Dutch citizens benefit from the successful penetration of NGA broadband. The network covers more than 95% of the area and in comparison to other countries the availability of high-speed internet does not dramatically decrease even in rural areas.[14] In Netherlands, the development of the broadband infrastructure started early before the European liberalisation, (van Eijk & Doorenspleet, 2014) however, the country lost its momentum. The austerity of Netherland's government brought about the reduction of ICT investments and the country struggles to keep up with major digital innovations in the present. (Chakravorti et al., 2015) The rest of Benelux does not differ from Netherland's case substantially, but in the connectivity sphere, these countries are still ahead of the rest of region.

Figure 4.5: Next Generation Access – national and rural coverage gap



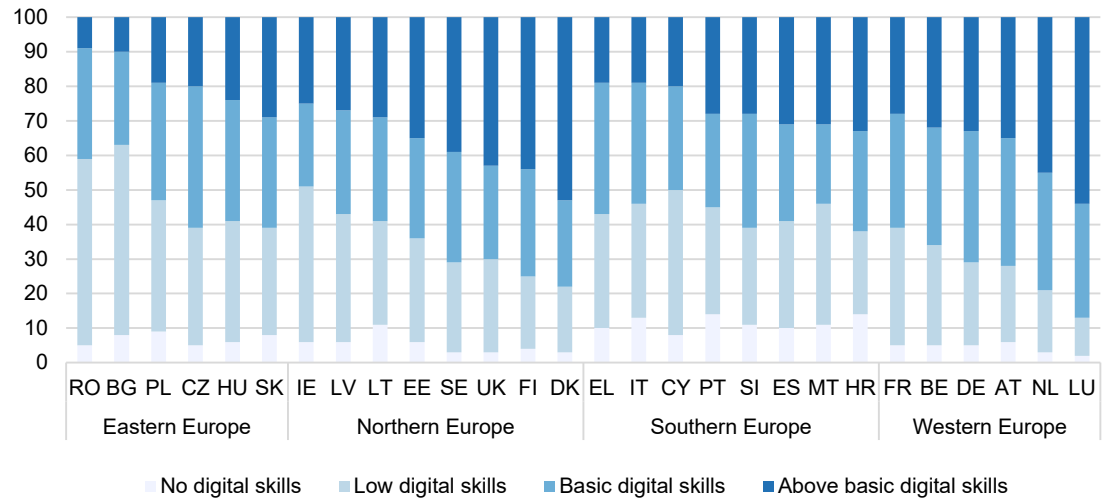
Source: Author based on European Commission - Broadband Coverage in Europe (2015)

According to the UN e-government development index, France belongs to the top 10 countries having the highest level of online public services. Nevertheless, the progress in recent years has been minimal and as a result brought about poor digitisation and introduction of fast broadband in the country. The digital literacy of France is below the region's average. These factors influence the quality of technology use for various

[14]EC - Broadband coverage in Europe (2015)

purposes. Since Figure 4.6 shows the values of internet users, it is easy to interpret the digital skills distribution in the counties, regardless of the penetration level.

Figure 4.6: Levels of digital skills of active internet users



Source: Author based on Eurostat - Individuals' level of digital skills (2016)

Central and Eastern Europe

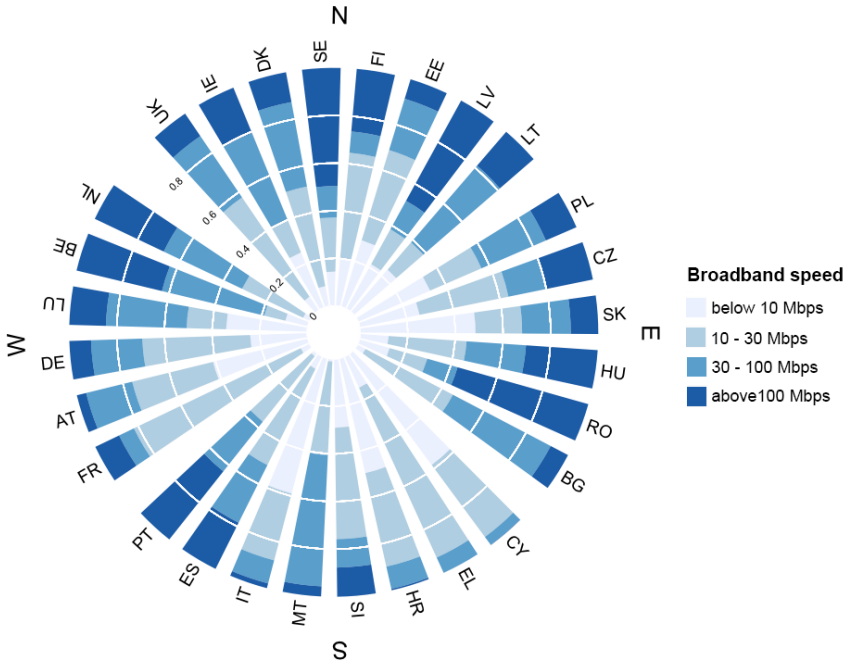
Southeast Europe, unlike Nordic and Western members, lag far behind based on many parameters. Romania and Bulgaria invest only a negligible part of the available European budget into information & communication technologies theme of ERDF and EAFRD.

Bulgaria has the biggest coverage gap between rural and urban areas, and it is not going to decrease in the future since the country decided to use only an insignificant part of its budget to finance citizen's digitisation and broadband networks from European Structural and Investment Funds between 2014 and 2020. 371 million euros are by far the lowest amount dedicated to ICT sector within Central and Eastern Europe. Underinvested technological industry could be critical for the elimination of differences in the European continent which is the exact opposite of the intentions of the European Commission. According to Eurostat, in 2016, 21% of Bulgarian households had no internet access in their homes due to the high prices of equipment or accession costs, another 15% mentioned they do not need internet access in their homes. The small promotion of digital technologies by the Bulgarian government and poor connectivity in the country could jeopardise the country's development.

The next EU member, Romania, contend with greatly diversified digital conditions. Although only 65 percent of households benefit from internet connection, more than half

of them can enjoy the ultra-fast broadband technology. As shown in Figure 4.7, the number is the highest in the whole EU, which is shocking taking into consideration underdevelopment in other aspects of the digital market. Nevertheless, Romania lags behind in many others digital indicators. The social exclusion of Roma citizens and lack of governmental steps towards transparency inhibit (not only) digital homogeneity of the country. (Bakó, 2016) Weak digital literacy in the Romanian market is one of the hindering factors. Nevertheless, there are other more serious obstacles that hinder Romania's digital development. The country is performing poorly in absolute numbers, but more importantly, the growth rate of the country in fields of e-commerce and e-government is the lowest among EU-28 members.

Figure 4.7: Share of fixed broadband according to connection speed



Source: Author based on Eurostat - Fixed broadband - subscriptions by speed (2016)

The Visegrad Group represented by the Czech Republic, Slovakia, Poland and Hungary overall performs slightly better than its south-eastern partners. They developed in similar historical conditions, share close relationships, values, traditions and ways of thinking. All these countries had to switch from centrally planned economies to a quite distinct concept of market economy. (Ziemba, Papaj, Zelazny, & Jadamus-Hacura, 2015) The results within the quartet are therefore rather ambiguous, and not a single country has attained extraordinary digital achievements.

Hungary dominates in terms of NGA coverage and adoption of fast broadband, nevertheless, according to Akamai 4Q 2016 internet connectivity report, the Czech Republic reached 17.3 Mbps average connectivity speed and was ranked fifth in the European Union. Critical for both countries is coverage in rural areas, which pushes down their potential.

The countries of the Visegrad Group could successfully compete with Southern Europe in e-commerce and digital literacy. The Czech Republic performs well in terms of online businesses transactions with 29% of enterprises having received orders via computer-mediated networks and Slovaks are leaders of the region with 56% share of online buyers in population. (see Figure 4.4) Slovakia performed quite well regarding digital skills measurement while Hungary has the upper hand in the employment of e-government.

On the contrary Poland and the Czech Republic wrestle with the introduction of ICT in public administration. Poland, with the highest investment from the EU,[15] makes a sizeable effort to improve e-government provision. However, legal problems and poor management of financial resources from structural funds, made the European Commission suspend financing of programs in 2012. (Popiołek, 2013) Concerns about security and protection of personal data decreased the popularity of e-government among the Poles themselves. The unawareness of e-government among citizens, businesses, as well as civil servants slows down the digitisation of public services. (Niklas, 2016) Analogous complications accompany the implementation of e-government in the Czech Republic, where many criticised baseless strategies by public institutions. The missing analysis in part of designing projects and poor evaluation of impacts reduced the transparency of political decisions. Moreover, many applications suffered from critical blackouts during their launch, which was reflected in restraint of Czech citizens towards the electronic government. (Špaček, 2014)

Southern Europe

From the geographical division, Slovenia accounts for Southern Europe, but the similarities in e-services and digital skills reassembles the performance of the Visegrad Group. As depicts Figure 4.5 and Figure 4.7 the country already started implementing NGA networks, however, the demand for faster connection is not sufficient, which is

[15] European Structural and Investment Funds – budget allocation (2014-2020)

partly caused by high costs. The low return on investments (ROI) of operators, therefore, does not stimulate them to introduce the 100 Mbps broadband at a rapid pace.

Malta dominates the EU in the NGA broadband coverage, as could be seen in Figure 4.5. The situation becomes a little bit more curious taking into considering the prices of the connection and uptake. Maltese providers offer nearly 100% coverage of ultra-fast (100 Mbps) fixed broadband connection but also for the highest retail prices in the whole of EU.[16] It is also one of the reasons that 55.2 percent of households were connected to 30-100 Mbps, but only 4.2% reached 100 Mbps plus download speed in 2016.[17]

By contrast, the Maltese neighbour, Italy, is surprisingly underdeveloped in the European digital sphere. Despite the comparable mean income to highly advanced western and northern economies, the country lags behind in nearly all digital aspects. The country is suffering from high public debt. Economy measures of the cabinet in recent years do not dedicate much attention to the digital economy, which is reflected in the minimal usage of e-services. The biggest threat to the country is, nevertheless, the digital literacy of citizens, which could inhibit the progress of Italy in the coming years.

Another island member state, Cyprus, has suffered from the late implementation of LTE technology. Households were not able to take advantage of fast mobile broadband until 2015. Based on this fact, the penetration of mobile broadband in the country is minimal. Only two percent of households are connected to mobile broadband. The similarity in mobile broadband is observable in Greece. Although Greeks spread the coverage of LTE in 2012, 10% of households still used mobile broadband in 2016. There is a visible gap in comparison to Finland with 85% households using mobile broadband.[18]

By contrast, in Spain, where in just four years (between 2011 and 2015) it managed to connect 53 percent of households, almost nearing Finnish success. This progress was the fastest in the whole European Union. Together with Portugal, these countries definitely account for the most internet coverage among the leaders of the region. High penetration of +100 Mbps broadband provides a solid starting point for digital development. On the

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[16] EC - Broadband Internet Access Cost (BIAC) – monthly charges in EUR/PPP (2015)

[17] Eurostat - Fixed broadband - subscriptions by speed (2016)

[18] EC - Broadband coverage in Europe (2016)

other side of the ultra-fast broadband spectrum, we find Croatia, Cyprus and Greece. In those countries, the penetration is virtually zero.

Quantitative Analysis

Data and Methodology

Model Structure

The empirical part of the thesis provides a detailed explanation of relationships between response and control variables. The first set of regressions should help the reader to understand mobile broadband adoption with regards to subscriptions as well as the share of households using it as an alternative or complement to fixed type. The dependence of fixed broadband penetration on the market is examined in three (advertised speed) categories. Finally, the indicators providing elucidation of e-services usage are presented. The general form for regression used in this work is explained by the following formula:

$$y_{it} = \beta_0 + \boldsymbol{\beta X_{it}} + a_i + u_{it}\ ;\ t = 1, \dots, T;\ i = 1, \dots, N$$

y_{it}	dependent variable
β_0	intercept (constant term)
$\boldsymbol{\beta}$	vector of estimated coefficients
$\boldsymbol{X_{it}}$	vector of explanatory variables
a_i	individual (country specific) effect
u_{it}	idiosyncratic error term

Three output tables available in the empirical part summarises the results of regressions. However, models require an altered combination of included explanatory and explained variables. The basic form of the model proceeds from the general structures formulated below. The final versions are modified to reach the required functionality and needs. Each formula is dedicated to one set of regressions. Variables selected for the models came from a wider range of potential indicators. Regression outputs in the empirical part provide an overview of them, and Appendix 2 including alternative versions supports the selection of those used in final models.

$$mobilebroadband_{it} = \beta_0 + \beta_1 coverage_{it} + \beta_2 price_{it} + \beta_3 economy_{it} + \beta_4 education_{it} + \beta_5 devices_{it} + \beta_6 demography_{it} + \beta_7 supply_{it} + a_i + u_{it}$$

$$fixedbroadband_{it} = \beta_0 + \beta_1 coverage_{it} + \beta_2 price_{it} + \beta_3 economy_{it} + \beta_4 education_{it} + \beta_5 devices_{it} + \beta_6 demography_{it} + a_i + u_{it}$$

$$eserviceuse_{it} = \beta_0 + \beta_1 penetaration_{it} + \beta_2 skills_{it} + \beta_3 education_{it} + \beta_4 economy_{it} + \beta_5 supply_{it} + a_i + u_{it}$$

Table 3.1: Key variables used in models

General form	Indicators	Description
mobilebroadband	MOB_PENET, TYPE_MOB, TYPE_MOBO	penetration and intensity of mobile broadband
fixedbroadband	TYPE_FIX, FIX_SPNGA, FIX_SP30, FIX_SP100	penetration and connection speed of fixed broadband
eserviceuse	ECOM_I, EGOV_I	a share of individuals using e-commerce and e-government
coverage	COVLTE, COVNGA, COVNGA.R, COV30, COV100	area of the country (R – rural areas) covered by selected technology
price	MOB_PR2000, FIX_MPR30, FIX_MPR100	lowest and (M) median prices of broadband connection
economy	MEDINC, GDPBIL	median income and gross domestic product
education	EDUC_HIGH, EDUC_MH	a share of individuals with a level of education (MH – medium or high)
devices	PENET_SIM, PENET_COMP	penetration of devices enabling internet connection
demography	U_RURAL, DENSITY	degree of urbanisation and density of population
penetration	TYPE_ALL, TYPE_FIX, TYPE_MOB	penetration of broadband
skills	CSKILLS_MH	a share of individuals with medium or high computer skills
supply	ECOM_E, EGOV_G, OPER	indicator of services offered by enterprises and government

Source: Author

Data

In the analysis, we predominantly use percentage levels, shares of population and standardised units, rather than absolute numbers as a count of households or citizens. One of the reasons is to reach the comparability of the countries irrespective of country size. Data for the purpose of research was collected from Eurostat data tables, Broadband coverage in Europe reports, Broadband Internet Access Cost (BIAC) studies, United Nations E-government Development Index and European Structural and Investment Fund Database. Time series dimension is ranges from 2004 to 2016. Nevertheless, the majority of digital indicators were not available until 2010. Definitions, units and specific sources, as well as descriptive statistics of used variables, are available in Appendix 4.

Methodology

For the examination of drivers' leverage we will perform random effects model (random), fixed effects estimation (within) and pooled ordinary least squares estimation (pooled). In the subsequent discussion and evaluation, we will work primarily with the best-predicted model.

The small size of the European Union (in a count of countries) does not provide a sufficient sample for the simple cross sections method. The modelling would, thus, lead to inaccurate estimations. Enlargement of the sample size by using data for a longer time period enables pooling of cross sections across time. The fixed effects (or within) estimation, examining the panel data, has an advantage over pooled cross sections in elimination of an unobserved (country) effect a_i, specific for each member state, and remaining constant over time. (Wooldridge, 2012)

Using the time demeaned data in the model, allows filtering out of the country specific effect. Therefore, it is possible to include even highly heterogeneous EU members in the regression. (Hsiao, 2006) The considerable digital and economic diversity among European countries favours the FE model. However, we use the percentage levels and comparable units which reduce the individual effect. Moreover, differences between years are not distinctive, which could endanger the preference for FE model. For the purpose of decision making, the F-test for individual effects will be performed to ascertain whether the fixed effects are present and the model is applicable in the particular case. (Wooldridge, 2012)

Another model appropriate for the empirical study is random effects model, which is commonly used together with the already presented FE. Random effects estimation is based on the assumption that the variation among the countries is random or uncorrelated with the explanatory variables. The advantage of RE model, in comparison to FE, is the possibility of using time-invariant variables. To discriminate between fixed effects and random effects models, we will run Hausman specification test (Bell & Jones, 2015) and Lagrange multiplier test will alternatively evaluate RE and pooled OLS models.

Before we immerse into dealing with potential complications in regression analysis, we should introduce the methods for a model specification. Since the study examines actual topics and relatively new technologies, availability of panel data does not allow us to use a single method only. Thus, the final specification of the models is the result of a combination of following steps:

- Include the key indicators for the research question and secondary variables
- Exclude the explanatory variables suffered from multicollinearity and with a lower statistical significance
- Combine the variables to reach at least 100 observations
- Using stepwise regression to choose the model with the highest explanatory power measured by adjusted R^2

Detailed provision of particular processes would be disproportionate; thus we only reflect some of the steps directly in the modelling part of our empirical study.

Among the first complications which could arise in the multiple regression analysis, emerges multicollinearity. We applied and analysed correlation matrixes for each combination of regressors to detect the Pearson's correlations between explanatory variables. In the literature, the critical bound is not precisely determined. Therefore, there exist several thresholds for multicollinearity. For this empirical study, if the matrix contained an absolute value higher than 0.7, we inspect the statistical significance of both indicators. One of the explanatory variables suffering from high pairwise correlation with lower significance in the model was removed from the regression.

Further (and more importantly) models were tested and alternatively controlled for heteroskedasticity. Breusch-Pagan test helped to detect whether the error terms variance depends on actual values of explanatory variables. In case the test rejects the null hypothesis of homoscedasticity, heteroskedasticity-robust standard errors replace those

in the original model to cope with the issue. The robust errors tend to be lower than in the original regression, therefore, by controlling for heteroskedasticity, estimators become more statistically significant. Eventually, the autocorrelation, or sometimes called serial correlation, represents another common problem accompanying the analysis of panel data. This issue results in invalid standard errors and therefore invalid statistical inference. (Wooldridge, 2012) Breusch-Godfrey test serves for detecting the serial correlation in models based on the p-value. In both cases proposed Driscoll and Kraay robust standard errors are used. (Hoechle, 2007) The heteroskedasticity and autocorrelation are tested at 5% significance level. In the regression outputs, both methods are labelled by HR and AC abbreviations when used. P-values for all tested hypotheses are accessible in Appendix 3.

Regressions in similar type of works contend with omitted variable bias. The simplified models tend to explain only part of the variation of dependent variables, and an author can simply omit important indicators revealing the influence. (Wooldridge, 2012) Models in the empirical part of this study take into consideration supply-side parameters, prices, wealth indicators, education levels and accessibility of the broadband. Omitted variables should be primary in the form of personal incentives and unobserved factors, thus in models where one of the principal variables is missing, we present an alternative form of the model with changed combinations of explanatory variables.

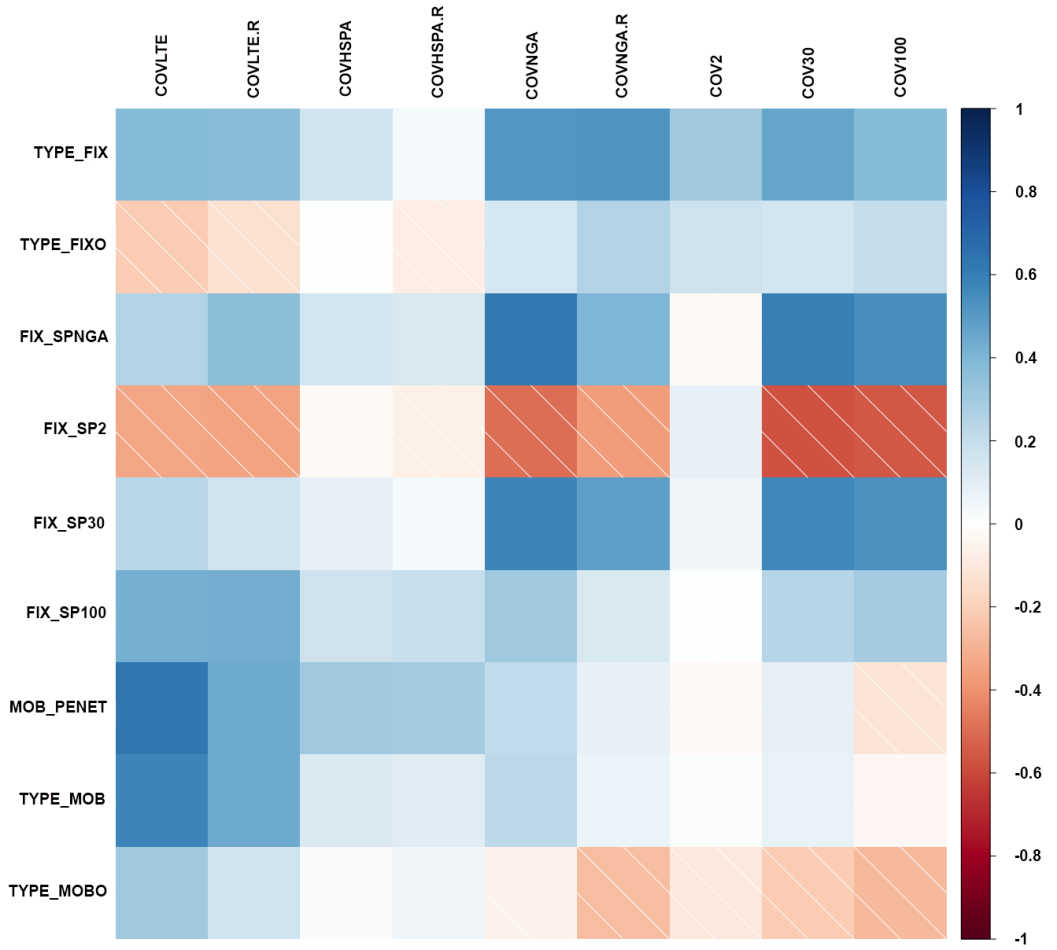
The last part of this section will be dedicated to the endogeneity of the variables. Despite the fact that some models contain explanatory variables, those previously explained, the instruments suffer from relatively low R-squared. As mentioned by Bound, Jaeger and Baker (1995) "*use of instruments that jointly explain little of the variation in the endogenous variable can do more harm than good*". On that basis, we decided not to utilise instrumental variables to cope with the endogeneity problem in the analysis. Also, the actual topic with limited availability of the overlapping data makes the use of instrumental variables hardly possible.

Descriptive and Regression Analysis

Qualitative analysis already uncovered some relations between the main variables. The empirical part should bring answers to research questions stated in the introduction of the thesis. Firstly, we will present the correlations between key determinants and explained variables. The second section is dedicated to modelling and discussion. The brief summary of results and limitations of the study will be covered in the next chapter.

Fixed and Mobile Broadband

Figure 5.1: Correlation plot – broadband coverage and penetration



Source: Author based on Eurostat, EC - Broadband indicators, EC - Broadband coverage in Europe, Digital Agenda Scoreboard (2008-2016)

The correlation plot depicted above, exposed some patterns in the decision-making of households regarding fixed and mobile broadband. The left bottom corner of Figure 5.1 shows the positive correlation of the mobile networks (COVLTE and COVHSPA) with the actual penetration of the mobile broadband (MOB_PENET), both in rural and all areas of the country. The results are in line with our expectations. The increase in impact in case of MOB_PENET variable is caused mainly because the indicator MOB_PENET shows the intensity with which mobile broadband is used. On the contrary, the share of households with only a mobile type of connection (TYPE_MOBO) reflects the need or necessity of mobile services, and the gives the first sign of fixed broadband substitution. In other words, the low coverage of Next-Generation Access (especially in rural areas)

(COVNGA.R) and ultra-fast fixed broadband (COV100) forces the households to opt for mobile internet, which offers them reasonable download speed.

Mobile technologies bring changes to the market of fixed broadband. The limitations of "next generation" mobile LTE networks (COV_LTE) are mirrored in a higher share of fix-only households (TYPE_FIXO). As can be seen from a deeper analysis of the correlation plot, the proportion of households with a slow connection (FIX_SP2) rapidly decreases with the superior coverage of LTE. HSPACOV(.R) numbers also support this inference of fixed-to-mobile substitution. However, the influence of older technology is weaker. It is important to be more aware of interpretation; the standard deviation of COVHSPA indicator is minimal. Used data source tracked the HSPA coverage since 2011 when 25 out of 27 countries already covered more than 90% of their territories.

The table below presents our regression results in relation to the first research question, with a focus on mobile broadband availability and take up. Specifications (1) and (2) are only models, where the Lagrange Multiplier and F tests respectively provided p-values of 0.032 and 0.014, which give the preference to random and fixed effects models. The significance of individual effect presence was for all models very low. Thus a majority of models use OLS as the favoured version. All p-values are available in Appendix 3.

Table 5.1: Mobile broadband - regression output

Dependent variable	**MOB_PENET**	**MOB_PENET**	**TYPE_MOB**	**TYPE_MOBO**
Model	random (HR)	within	pooled (HR, AC)	pooled (HR, AC)
No.	(1)	(2)	(3)	(4)
COVLTE		0.170***	0.247***	0.046***
		(0.062)	(0.019)	(0.010)
COVNGA.R		-0.232***	-0.069*	-0.090***
		(0.062)	(0.039)	(0.021)
EDUC_HIGH	0.750***	1.282***		
	(0.052)	(0.243)		
MOB_PR2000	-0.731***			
	(0.045)			
MEDINC		0.826***	0.347***	0.209***
		(0.202)	(0.039)	(0.037)
DENSITY		0.021***		
		(0.008)		
GDPBIL	-0.005***	-0.006***	-0.0001	-0.001***
	(0.001)	(0.002)	(0.001)	(0.0003)
SIM_PENET		0.193***	0.043	0.094***
		(0.051)	(0.038)	(0.013)
OPER		7.863***	0.063	0.535
		(1.310)	(0.463)	(0.359)
Constant	92.210***		1.814	-10.342***
	(4.084)		(5.691)	(2.178)
Observations	56	137	135	134
Adjusted R^2	0.470	0.589	0.331	0.412
F Statistic	17.153*** (df = 3; 52)	26.644*** (df = 8; 118)	12.053*** (df = 6; 128)	16.511*** (df = 6; 127)
Note:				*p<0.1; **p<0.05; ***p<0.01

Source: Author based on Eurostat, EC - Mobile Broadband Prices, EC - Broadband coverage in Europe, Digital Agenda Scoreboard (2004-2016)

First two models serve for the examination of the mobile internet penetration characterised by active SIM-cards with mobile broadband (MOB_PENET). Due to only two years of price data, we were not able to construct the single model containing all explanatory variables. Models (3) and (4) investigate the representation of mobile

broadband in households as it could be the complementary or substitute service to fixed connection.

Tertiary education (EDUC_HIGH) plays a major role in using mobile broadband through cell phones. This fact can be explained by the occurrence of company phones in a business branch. Dual-SIM smartphones nowadays enable people to possess multiple active SIM-cards in one device. Therefore, more countries reach mobile penetration of above 100% level. For the use of mobile internet in households, the education parameter brings highly insignificant results. Thus, it is not included in the model. On the other hand, the positive effect of income, measured by median value (MEDINC), is statistically significant at 1% level in all three regressions where this indicator occurred. Model (1) on top of that detected a strong negative relationship between the penetration and cost of a 2GB mobile data package (MOB_PR2000). We tested the model with 100Mb package alternative, however, the larger package proved to be more determinative. Only 56 observations and three used independent variables in the model limit the robustness and reliability of regression results.

Speaking of the economic size of the country measured by GDPBIL, all four regressions indicate that the bigger ones are slower in the adoption of mobile broadband. Only in model (3), the standard error is relatively high compared to estimator magnitude. The smaller countries seem to be more dynamic in adoption of new technologies. Similar behaviour showed the penetration of all active SIM-cards (SIM_PENET) which was positive but insignificant in the TYPE_MOB model. Unfortunately, we were not able to detect better explanatory variables and thus adjusted R-squared is the lowest among all presented regressions.

OPER is a rough proxy parameter for measuring the competitiveness of the market, the higher number of active operators, keeping all other variables constant, resulted in a higher penetration in all models, nevertheless, it showed to be statistically significant only in the MOB_PENT model. DENSITY is explaining the fact that more densely populated countries tend to have, ceteris paribus, the higher adoption rate of mobile broadband. Similarly as EDUC_HIGH, this parameter was not included in models (3) and (4), because of the low explanatory power.

Finally, we discuss the relevancy of the parameters, which are key for a stated research question. As can be seen, much variation in models is explained by coverage indicators.

The absence of fixed NGA in rural areas (COVNGA.R) intensifies the adoption of the mobile internet in households. The effect is even stronger and more relevant for households using the mobile broadband only. The significant negative effect appeared in three main models. Conversely LTE technology coverage (COVLTE), not surprisingly, is positively related to the mobile broadband penetration. Using heteroskedasticity robust errors in models (3) and (4) increased the significance of estimators. Since it emerged that HSPACOV is an irrelevant explanatory variable for the given model structure, we did not include it in modelling. The LTE technology thus seems to be one of the essential drivers of mobile broadband penetration in households. The p-value of COVLTE in the model with TYPE_MOB regress and is virtually zero.

Models describing a mobile broadband suffer from relatively low adjusted R^2 values. Thus only a minor part of the variation in predicted variables is explained in models. Slightly better adjusted R^2 values provide the fixed broadband penetration regressions available in Table 5.2.

Table 5.2: Fixed broadband - regression output

Dependent variable	**TYPE_FIX**	**FIX_SPNGA**	**FIX_SP30**	**FIX_SP100**
Model	pooled (HR)	pooled (AC)	pooled	pooled (AC)
No.	(5)	(6)	(7)	(8)
COVNGA	0.124***	0.585***		
	(0.029)	(0.094)		
COV30			0.355***	
			(0.063)	
FIX_MPR30		-0.665***	-0.345***	
		(0.025)	(0.076)	
COV100				0.233***
				(0.049)
FIX_MPR100				-0.183***
				(0.056)
MEDINC		-0.388***	0.045	-0.171***
		(0.066)	(0.162)	(0.056)
U_RURAL		-0.408***		
		(0.101)		
EDUC_MH	0.192***	-0.289***	-0.320***	-0.103**
	(0.030)	(0.068)	(0.117)	(0.049)
DENSITY	0.013***			
	(0.001)			
TYPE_MOBO			-0.625***	0.671***
			(0.191)	(0.104)
GDPBIL	0.003***	-0.011***	-0.003*	-0.002***
	(0.001)	(0.001)	(0.002)	(0.001)
COMP_PENET	0.565***			
	(0.074)			
Constant	-4.655	69.607***	38.839***	15.365***
	(4.706)	(8.624)	(11.946)	(4.232)
Observations	110	108	80	50
Adjusted R^2	0.710	0.713	0.467	0.343
F Statistic	54.463*** (df = 5; 104)	45.274*** (df = 6; 101)	12.545*** (df = 6; 73)	5.263*** (df = 6; 43)

Note: *p<0.1; **p<0.05; ***p<0.01

Source: Author based on Eurostat, EC - Broadband Internet Access Cost, EC - Broadband coverage in Europe, EC - Broadband indicators (2004-2016)

We attempted to include similar types of determinants as in the previous set of models for fixed broadband. All coverage estimators (COVNGA, COV30, COV100) confirm their importance for penetration. Households tend to take advantage of faster internet connection if the service is available in their country. Thanks to the low standard errors coverage parameters which are statistically significant in all four models at 1 % level. The significance decreases for 100+ Mbps broadband, but the decline is minimal.

Model (6) and (8) in which the share of subscriptions with NGA and 100+ Mbps (FIX_SPNGA, FIX_SP100) are dependent variables, demonstrates an interesting fact, that MEDINC has negative effect – ceteris paribus - on the adoption of fixed broadband. We also tested versions with mean income variable, which concluded with similar results. In model (7) MEDINC variable gains the positive sign of the estimators, however, the high p-value means a low significance of the estimator. Initially we included the income factor in model (5), nevertheless there is a possibility to include a more relevant COMP_PENET indicator. Penetration of computers in households suffers from a high multicollinearity with the MEDINC parameter. We decided to continue only with COMP_PENET. EDUC_MH parameter, denoting the share of the population with at least secondary education, clarifying the dependent variables in the same manner. Based on these values, the wealth and higher education are relevant for the presence of fixed broadband in households, but they do not represent drivers of fast and ultra-fast broadband adoption.

The median retail price is negatively associated with the share of fast and ultra-fast fixed broadband, thus also, in this case, costs influence subscribers' decisions. For TYPE_FIX we did not find the suitable price indicator; Therefore, this parameter is missing. The cost of the service determines, however, the proportion of fast and ultra-fast internet connections. The effect transpires to be statistically significant in all three models. Estimates for GDPBIL describe, similar to the first set of models, slower adoption of newer technologies (faster broadband) in larger economies. The fixed broadband penetration (TYPE_FIX) showed a positive effect on gross domestic product; however, the share of households with a fixed type of connection had a tendency to decrease in the last years. (see Figure 2.1)

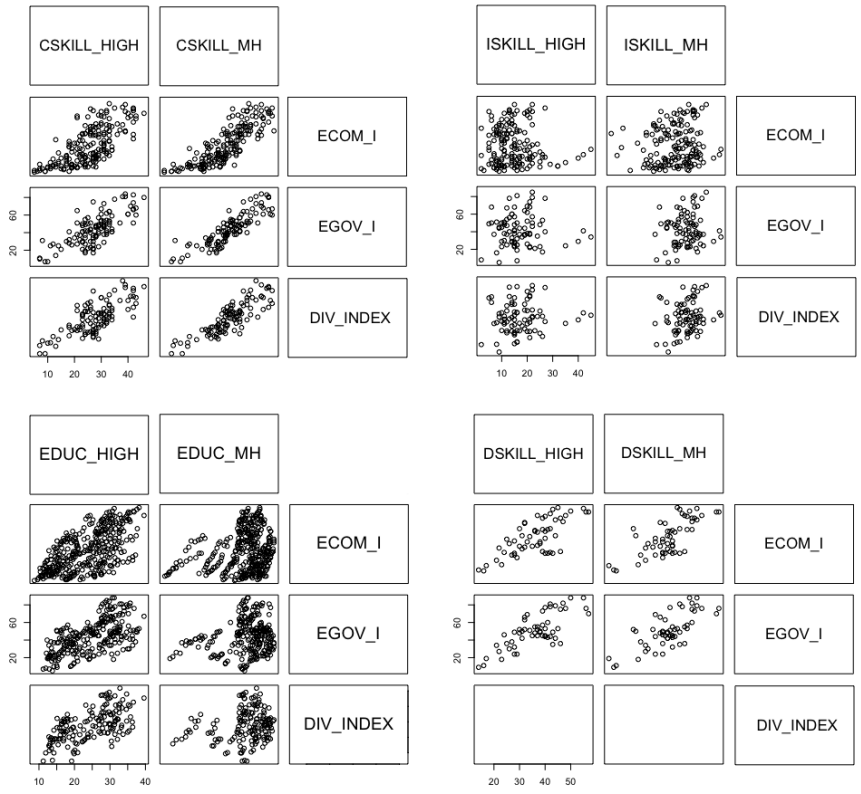
The explanatory variable TYPE_MOBO should help to explain the fixed-to-mobile broadband substitution, in which households with inferior fixed broadband coverage are more likely switching to mobile networks. This inference was also shown in the

correlation plot. In the case where the LTE coverage is available while the coverage of ultra-fast broadband is small, the households with slow fixed internet tend to switch to the mobile type. Model (8) was predicted based on 50 observations and the calculated adjusted R-squared belongs to the lowest. Thus, the explanatory power of regression could be limited.

As interpreted in the analysis of fixed and mobile broadband, slow internet represented by HSPA and non-NGA technologies does not play a crucial role while studying the influence on penetration in this case. The boom period of those services already passed and many Europeans already upgraded their obsolete connections. Coverage of 30 Mbps and NGA technologies apparently explains much variation of the actual connectivity through the particular services, while the pace of ultra-fast broadband adoption has not necessarily been determined by the coverage of 100+ Mbps internet, which still has potential to compete with mobile broadband.

E-services Usage

Figure 5.2: Scatterplots – human capital and e-services usage



Source: Author based on Eurostat (2004-2016)

Data available for the second research question provide more anticipated correlations than in the first part. Figure 5.2 captures the dependence of e-commerce and e-government individuals' usage of education parameters and skills.

At the bottom right corner, we can see that high (DSKILL_HIGH) and also medium or high (DSKILL_MH) digital skills are positively correlated with the e-government and e-commerce online activities. Eurostat first established this new metric in 2015 as a replacement for internet and computer skills. The shortage of observations, however, does not allow us to include them in the regression analysis.

Quite surprising could be the distribution of e-services use based on internet literacy. ISKILL_HIGH and ISKILL_MH indicators do not produce any structure implying the dependence on usage variables. On the contrary, the best projection of online activities shows a high level of computer skills. We calculated a new metric CSKILL_MH, which equals the share of the population with at least medium computer skills. There is noticeable increasing linear trend of CSKILL_MH and both e-services (ECOM_I, EGOV_I). For the case of e-government, the correlation coefficient reaches a maximum of 0.8625.

We handle education determinants similarly to the case of skills. EDUC_HIGH represents the share of the population with tertiary education. This variable is unsurprisingly positively correlated with e-services usage. Nevertheless, here the variance is much higher. Malta, Spain and Portugal lag behind the rest of the EU in the share of the population with at least secondary education. Therefore, MH type of indicator could be slightly deviated. In total, the schooling seems to be relevant, but the computer skills are expected to bring higher impact and more significant results in subsequent regression.

The last variable situated next to the e-commerce and e-government use is the diversification index (DIV_INDEX), presented by Eurostat. This parameter measures the average number of online activities (out of a list of 12) performed by internet users in the previous three months. In this work, the index helps to validate the inference for e-services in general. Unfortunately, data was not available since 2014, and therefore the correlation between the diversification index and digital skills cannot be tested. In all other cases, this indicator confirmed the outcomes above.

Table 5.3: E-government & e-commerce - regression Output

Dependent variable	**EGOV_I**	**EGOV_I**	**ECOM_I**	**ECOM_I**
Model	pooled	pooled	pooled	pooled (AC)
No.	(9)	(10)	(11)	(12)
CSKILL_MH		0.927***		0.796***
		(0.104)		(0.069)
ECOM_E			0.393***	0.512***
			(0.100)	(0.075)
EDUC_MH	0.210***	0.047	0.194***	0.046
	(0.070)	(0.076)	(0.049)	(0.034)
EGOV_G	0.479***			
	(0.136)			
GDPBIL	-0.005***	-0.002*	0.003***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
MEDINC	0.731***		1.064***	
	(0.137)		(0.088)	
TYPE_ALL	0.498***		0.749***	
	(0.072)		(0.059)	
TYPE_FIX		0.192***		0.148***
		(0.065)		(0.040)
TYPE_MOB		0.350***		0.595***
		(0.098)		(0.040)
Constant	-45.241***	-31.364***	-48.304***	-56.764***
	(8.283)	(7.014)	(4.223)	(5.809)
Observations	112	83	169	83
Adjusted R^2	0.775	0.774	0.883	0.846
F Statistic	77.582*** (df = 5; 106)	57.217*** (df = 5; 77)	255.203*** (df = 5; 163)	75.951*** (df = 6; 76)

Note: *p<0.1; **p<0.05; ***p<0.01

Source: Author based on Eurostat, United Nations, EC - Broadband indicators, Digital Agenda Scoreboard (2004-2016)

The final part of the empirical study tries to put an interpretation on the usage of e-services in the EU. All the models in the empirical study were tested for the presence of individual effects by using the F test. Nevertheless, p-values for this set of regressions ranges high - between 0.197 and 0.670. Thus we failed to reject the null hypothesis of individual (country specific) effects. Moreover, p-value in Breusch-Godfrey test for serial correlation in the model (12) is only 0.001, which means we rejected the null hypothesis

- no serial correlation at 1% level. By subsequently used Driscoll & Kraay robust covariance matrix estimator we obtained robust standard errors.

From the analysis of the e-commerce and e-government models, it is evident that the level of supply side on the market, represented by ECOM_E and EGOV_G, constitutes substantial drivers of individual's usage. In other words, the higher is the share of domestic enterprises receiving orders online, the larger percentage of citizens purchases products and services online. In the second instance, the e-government development index constitutes the predicting variable increasing the actual usage, holding other factors constant. Unfortunately, the EGOV_G parameter could not be included in the model (10) due to a limited overlap of data with CSKILL_MH variable. Multicollinearity test also showed inadmissible correlation (0.7476) of computer skills (CSKILL_MH) with income, for that reason we do not include MEDINC explanatory variable in models (10) and (12) and CSKILL_MH was excluded from (9) and (11).

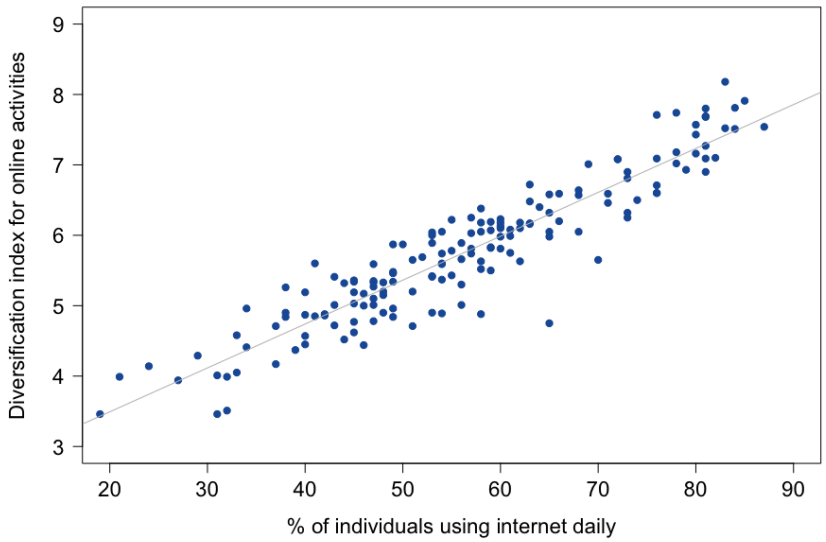
The parameter of gross domestic product showed that bigger economies have, ceteris paribus, superior results in e-commerce field, but on the other hand, the introduction of e-government is more complicated for them. The coefficients in all four models are statistically significant at 10% level. The likely effect demonstrates the broadband penetration regressors. Both, mobile and fixed broadband shows the positive impact on e-services utilisation. Stepwise regression showed that the models with TYPE_ALL explained the variation of predicted variables to very much the same degree as a combination of TYPE_FIX and TYPE_MOB. We included both versions. The coefficients and standard errors indicate the higher effect of mobile broadband.

Calculated p-values for CSKILL_MH coefficients were almost zero. The influence of computer skills on the usage of e-government and e-commerce is un-debatable. The impact is the highest from all used explanatory variables. A further effect of education on e-government and e-commerce proves ambiguous results. Models (9) and (11) indicate positive impact of education, keeping the all other regressors constant. In the case of inclusion of computer skills in the model, the effect of education disappears, and estimators become statistically insignificant. It is important to realise that education is positively correlated with income level, adoption of broadband (see Figure 4.2) as well as computer skills. In fact, the correlation coefficient between e-services activity and education is positive despite the mixed estimates in the models. If other parameters are constant, the schooling and computer skills have a slightly higher effect on the e-

government case. It could be caused basically by greater complexity of online activities than in the case of purchasing goods and services.

In the last set of models, high adjusted R^2 values denote a variation of regressands is explained to a high degree. Nevertheless, we go further into the examination of e-services usage. The suspicious correlation of the diversification index with a frequency of internet usage, represented by the share of individuals using the internet daily, leads to the next plot. The perfect predictability of e-services usage by frequency supports the fact that people tend to replace the standard services by their electronic form. The more time people spent online, the higher amount of activities they performed electronically. The frequency of internet usage is a very endogenous variable and moreover highly correlated with several explanatory variables in the third set of models. Therefore, the FQ_DAILY variable was not included in regressions.

Figure 5.1: Relation of frequency with the diversification of internet usage



Source: Author based on Eurostat - Individuals - frequency of internet use, diversification index for the activities realised online by internet users (2009 - 2016)

Results Summary and Discussion

The previous part of the analysis showed the underlying correlations between individual variables; and presented statistical modelling. Despite the fact that in the empirical analysis we used three different types of models (random effects, fixed effects and pooled OLS), the pooled OLS version produced the most precise results in 10 out of 12 regressions. The presence of individual effect was rejected in 10 cases at the 5%

significance level. This fact should not, however, reduce the plausibility of models. Appendix 2 contains available alternative (within or pooled OLS) models with p-values for determinative tests. They were used for elimination of potentially misleading estimators. The magnitudes and significance of estimators, however, do not fundamentally differ from those commented in the previous part.

Concerning the first research question, the study revealed the significant influence of coverage on the representation of broadband types on the EU market. The minimum of fast broadband coverage (mobile and fixed) proved to be critical for fixed-to-mobile substitution in member states. Countries, where a high share of subscribers benefits from 100+ Mbps internet connection, are less influenced by fixed-to-mobile broadband substitution. The regressions, however, depicted the proportion of subscriptions with 30-100 Mbps broadband decrease with a growth of mobile-only households. The most affected are households with non-NGA broadband. They either upgrade for faster fixed connection or choose its mobile alternative.

The unavailability of ultra-fast fixed services thus motivates households to opt for mobile connection type. Subscribers have a tendency to keep the fixed broadband as long as it provides them with a significantly higher speed of connection. However, advantages of fixed connection vanish. The prices which proved to be an important determinant of the penetration, could potentially slow down the fixed-to-mobile substitution. Regression models show that although retail prices of broadband constantly decrease, the price sensitivity is still large. Members with higher costs reduce the penetration of fast and ultra-fast fixed broadband and people are less prone to adopt mobile internet if reasonable data tariffs are expensive. However, new caps for the roaming charges within the EU planned as of 15 June 2017 (Council of the EU, 2017) will make mobile broadband more affordable for a wider society. An increase of competitiveness on the market should be the next target for member states. A higher number of mobile operators could lead to a further decrease of retail prices, and help cover a higher share of the population with mobile broadband and increase the penetration of the mobile broadband.

The study also examined the impact on the rural areas taking into consideration urbanisation degree. Since the rural parts of EU member states suffer from low simultaneity of fast fixed and mobile broadband coverage, the less urbanised areas are more influenced by coverage parameters. On that basis, the European Union should not excessively foster the NGA coverage in areas where LTE serves as an equivalent. The

installation of optical fibres in rural areas is relatively costly, and therefore reduces ROI of companies. If providers focus on the development of high-speed network in populous urban agglomeration, they can compete with mobile operators and offer ultra-fast internet connection at lower costs.

Member states should eliminate mobile broadband coverage deficiency in less urbanised areas or places where fast broadband coverage is still missing. For rural parts of the European Union, reasonable connectivity speed constitutes the overlook for the decrease in the digital gap and higher competitiveness. At the time when more and more jobs are mediated through the internet and the dependency of the workplace drops, the fast broadband can slow down urbanisation. It could help the firms acquire workers from rural areas who do not want to relocate for a job, prevent overpopulation of cities and bring the spill-over into other many spheres of the economy.

Education and wealth parameters clarify other crucial impacts of connectivity. Both indicators belong to the drivers of high mobile broadband representation in households. However, the surprising fact is that tendency to upgrade for ultra-fast fixed broadband in countries with higher median income is lower. They therefore do not gain advantage of 100+ Mbps fixed connection even if it is accessible to them.

In the second research question, we examined the impact of human capital on actual utilisation of e-services. The initial investigation uncovered the positive correlations of education, digital skills and e-services use. Nevertheless, the empirical analysis demonstrated that when it is accounted for computer skills, the effect of education on usage is insignificant and close to zero. Computer skills, thus provide a better projection of involvement in e-commerce and e-government.

Although the effect of education on computer and internet skills are ambiguous, schools hold the potential to reduce those imperfections. The conservatism and over regulation of education system inhibit growth, and the EU struggles from the little leverage on digital skills. This sector holds the opportunity and, as was inferred in the study, the higher digital knowledge of citizens raises the use of e-services. Nevertheless, the crucial aspects are also dependent on lifelong self-learning.

The economic size of the country, measured by gross domestic product, was integrated into all examined models. It highlighted the higher momentum of smaller economies in the digital aspects. They perform much better in the adoption of new broadband

technologies and not only that; e-services models also showed they successfully integrate e-government; in which they can bring higher benefits to their citizens. Unfortunately, a small market size brings the disadvantage of narrower choices for sellers and does not favour small economies in the e-commerce field. Thus, especially for them the EU digital single market strategy, enhancing the cross-border e-commerce, could be the boon.

Limitations of the Empirical Approach

The unavailability of data highly disadvantages the research. Due to relatively new technologies, institutions do not provide sufficient time series to obtain satisfactory panel data. We tried to reach at least 100 degrees of freedom in each model. Unfortunately, semi-annual or quarterly time series are currently inaccessible for the majority of variables. Thus regressions are performed on an annual basis only. For that reason, we constructed more models to infer the conclusions with higher certainty. The suspicion of endogeneity is quite high especially in e-services set of models. The scarcity of simultaneous data points, however, does not allow us to use efficient instrumental variables.

The complicated caption of some indicators presents another problem in the models. Although the mobile broadband prices are available in datasets by EC, the composition of tariffs varies across the operators and countries substantially. The impact of mobile prices on the decision making of subscribers is beyond the scope of this study. Another difficulty caused changes in measurement methods. Since the Eurostat altered the metrics for capturing computer/internet skills, it would not be possible to achieve consistency in one single variable. Therefore, we are not able to work with one long-term indicator in all intended models.

The thesis compares the member states of the European Union, however, as was mentioned earlier, differences between the world digital leaders and the EU members are still significant and worth studying in deeper context.

Conclusion

The contribution of this work to current literature is mainly in exploring the patterns of the coverage parameters on fixed-to-mobile broadband substitution in the European Union. Employing recent panel data, we were able to introduce the impacts of new broadband technologies at a national level as well as in rural areas. Subsequently, the

importance of computer skills with indicators of education level helped to illustrate the digital divide in e-services usage.

The empirical part of the study demonstrated that the development of ultra-fast fixed networks should definitely be perceived as one of the critical policies. Nevertheless, the regulation of the fixed broadband market in the EU is not very strict. On the contrary, the positive influence of a higher number of operators on the mobile broadband adoption indicates the moderate regulation and openness of the mobile broadband market which serves as the driver for successful integration of mobile broadband in the society.

Unless the European Union particularly increases the magnitude of reasonable and diverse internet use, a provision of excessive funds for the introduction of faster networks is not the solution. In actual sense, knowledge-based growth of the economy belongs to its primary targets which should be reflected by its policies. For European countries, it is essential to enhance information and strategic skills. The ultra-fast internet itself will not increase the productivity or induce the positive economic impacts if it is employed in an unreasonable way. Conversely, the inefficient use of the internet could cause many adverse consequences.

Successful integration models of e-services based on Northern Europe could also help bring more efficient governance of critical fields. Despite DAE targets reflection on key areas of future digital development, countries should not strive for high percentage levels but actual e-government implementation and tangible results e.g. e-ID application. In this field, governments can directly attain their largest contribution. Similarly, the unification of complex regulations could accelerate cross-border e-commerce and create new opportunities on the European market.

This thesis does not strive to infer the precise impact of particular elements on digital economy development. The analysis should rather provide an indication of changes in the broadband market. Better availability of data in coming years would particularise the regression results. Nevertheless, we already projected the main patterns of households and individuals in the question of fixed-to-mobile broadband substitution and described resulting activities performed online. The study examines the development in the region, which belongs among the most watched in the world. The power of governments, as well as EU institutions, is sizeable and the rapid advancement of technology nowadays reveals great opportunities for economic growth. On the other hand, it provides only little space

for examination of policies and progress impacts within a short period and alternatively execution of necessary measures.

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Appendices

Appendix 1: Country Codes and Regional Division

COUNTRY	CODE	REGION
Bulgaria	BG	Eastern Europe
Czech Republic	CZ	
Hungary	HU	
Poland	PL	
Romania	RO	
Slovakia	SK	
Denmark	DK	Northern Europe
Estonia	EE	
Ireland	IE	
Latvia	LV	
Lithuania	LT	
Finland	FI	
Sweden	SE	
United Kingdom	UK	
Greece	EL	Southern Europe
Spain	ES	
Croatia	HR	
Italy	IT	
Cyprus	CY	
Malta	MT	
Portugal	PT	
Slovenia	SI	
Belgium	BE	Western Europe
Germany	DE	
France	FR	
Luxembourg	LU	
Netherlands	NL	
Austria	AT	

Source: Author based on United Nations Statistic Division - Geographic Regions (1999), Eurostat – Geography Glossary (2016)

Appendix 2: Alternative Regress Models

Dependent variable	**MOB_PENET**	**MOB_PENET**	**TYPE_MOB**	**TYPE_MOBO**
Model	pooling (HR)	pooling	within (HR, AC)	within (HR, AC)
No.	(1A)	(2A)	(3A)	(4A)
COVLTE		0.430***	0.270***	0.049***
		(0.032)	(0.018)	(0.010)
COVNGA.R		-0.266***	-0.076**	-0.092***
		(0.065)	(0.036)	(0.021)
EDUC_HIGH	0.889***	1.460***		
	(0.177)	(0.260)		
MOB_PR2000	-0.645***			
	(0.059)			
MEDINC		0.486**	0.339***	0.211***
		(0.202)	(0.041)	(0.037)
DENSITY		0.023***		
		(0.008)		
GDPBIL	-0.004***	-0.005***	-0.0001	-0.001***
	(0.001)	(0.002)	(0.001)	(0.0003)
SIM_PENET		0.150***	0.038	0.094***
		(0.053)	(0.040)	(0.014)
OPER		6.230***	-0.039	0.457
		(1.306)	(0.351)	(0.345)
Constant	85.146***	-44.934***	2.070	-10.146***
	(5.751)	(10.228)	(5.458)	(2.334)
Observations	56	137	135	134
Adjusted R^2	0.411	0.766	0.539	0.423
F Statistic	13.809***	56.715***	27.137***	17.257***
F Test p-value		0.01388	0.96970	0.73607
LM Test p-value	0.03157			

Dependent variable	**TYPE_FIX**	**FIX_SPNGA**	**FIX_SP30**	**FIX_SP100**
Model	within (HR)	within (AC)	within	within (AC)
No.	(5A)	(6A)	(7A)	(8A)
COVNGA	0.084***	0.535***		
	(0.022)	(0.097)		
COV30			0.349***	
			(0.066)	
FIX_MPR30		-0.658***	-0.375***	
		(0.035)	(0.079)	
COV100				0.230***
				(0.044)
FIX_MPR100				-0.185***
				(0.050)
MEDINC		-0.335**	0.081	-0.180***
		(0.065)	(0.164)	(0.044)
U_RURAL		-0.366***		
		(0.100)		
EDUC_MH	0.155***	-0.332**	-0.369***	-0.066
	(0.027)	(0.065)	(0.122)	(0.042)
DENSITY	0.014***			
	(0.002)			
TYPE_MOBO			-0.574***	0.801***
			(0.196)	(0.118)
GDPBIL	0.002***	-0.011***	-0.003*	-0.002***
	(0.001)	(0.002)	(0.002)	(0.0004)
COMP_PENET	0.567***			
	(0.070)			
Observations	110	108	80	50
Adjusted R^2	0.672	0.665	0.413	0.307
F Statistic	47.425***	37.766***	11.259***	5.292**
F Test p-value	0.09951	0.18208	0.54088	0.12386

Dependent variable	**EGOV_I**	**EGOV_I**	**ECOM_I**	**ECOM_I**
Model	within	within	within	within (AC)
No.	(9A)	(10A)	(11A)	(12A)
CSKILL_MH		0.905***		0.843***
		(0.125)		(0.075)
ECOM_E			0.372***	0.512***
			(0.106)	(0.088)
EDUC_MH	0.219***	0.023	0.218***	0.053
	(0.071)	(0.080)	(0.051)	(0.048)
EGOV_G	0.592***			
	(0.172)			
GDPBIL	-0.005***	-0.003**	0.003***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
MEDINC	0.695***		1.038***	
	(0.155)		(0.097)	
TYPE_ALL	0.484***		0.808***	
	(0.117)		(0.080)	
TYPE_MOB		0.208**		0.126***
		(0.082)		(0.046)
TYPE_FIX		0.369***		0.572***
		(0.118)		(0.066)
Observations	112	83	169	83
Adjusted R^2	0.740	0.754	0.871	0.835
F Statistic	66.726***	52.638***	230.523***	71.465***
F Test p-value	0.19664	0.58838	0.66976	0.65524

Appendix 3: P-values for Hypotheses Testing

No.	LM test	Hausman test	F test	Breusch-Pagan test	Breusch-Godfrey test
(1)	0.03157	0.47563	0.01148	0.00410	0.25651
(2)	0.46382	0.00003	0.01388	0.13739	0.17436
(3)	0.97201	0.74798	0.96970	0.00001	0.00004
(4)	0.80989	0.44041	0.73607	0.00000	0.03297
(5)	0.19853	0.00000	0.09951	0.03537	0.78618
(6)	0.32279	0.02215	0.18208	0.29122	0.04549
(7)	0.67738	0.68002	0.54088	0.17066	0.49157
(8)	0.12830	1.00000	0.12386	0.25448	0.01440
(9)	0.59670	0.65188	0.19664	0.56218	0.45514
(10)	0.73086	0.23308	0.58838	0.92581	0.81511
(11)	0.75901	0.00226	0.66976	0.06155	0.27698
(12)	0.83701	0.33128	0.65524	0.12090	0.00117

Appendix 4: Indicators, Data Sources and Descriptive Statistics

INDICATOR	DEFINITON	SOURCE	UNIT	MIN	MAX	MEAN	SD	OBS
COMP_PENET	Households having access to, via one of its members, a computer	Eurostat	% of households	21.00	96.00	69.3	15.26	250
COV100	Total land area covered by fixed broadband at speed 100 Mbps	EC - Broadband coverage in Europe	% of total land area	0.38	99.97	56.9	28.02	84
COV2	Total land area covered by fixed broadband at speed 2 Mbps	EC - Broadband coverage in Europe	% of total land area	76.12	99.99	95.7	5.24	84
COV30	Total land area covered by fixed broadband at speed 30 Mbps	EC - Broadband coverage in Europe	% of total land area	13.53	99.97	72.0	20.95	84
COVHSPA	Total land area covered by HSPA	EC - Broadband coverage in Europe	% of total land area	85.54	100.00	97.3	3.20	139
COVHSPA.R	Rural area covered by HSPA	EC - Broadband coverage in Europe	% of rural land area	7.66	100.00	87.4	14.73	138
COVLTE	Total land area covered by LTE	EC - Broadband coverage in Europe	% of total land area	0.00	99.62	49.4	35.94	139
COVLTE.R	Rural area covered by NGA	EC - Broadband coverage in Europe	% of rural land area	0.00	99.00	22.8	32.24	138
COVNGA	Total land area covered by NGA	EC - Broadband coverage in Europe	% of total land area	0.04	100.00	68.5	22.48	139
COVNGA.R	Rural area covered by NGA	EC - Broadband coverage in Europe	% of rural land area	0.00	100.00	29.2	29.88	138
CSKILL_HIGH	Individuals who have carried out 5 or 6 of the 6 computer related activities	Eurostat	% of individuals	5	46	25.4	8.73	187
CSKILL_MH	Individuals who have carried out at least 3 of the 6 computer related activities	Eurostat	% of individuals	15	76	49.0	13.16	187
DENSITY	Population density	Eurostat	inhabitants per km^2	17.20	1369.50	171.0	242.76	335

INDICATOR	DEFINITON	SOURCE	UNIT	MIN	MAX	MEAN	SD	OBS
DIV_INDEX	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.	Eurostat	activities	3.46	8.18	5.8	1.01	160
DSKILL_HIGH	Individuals who have above basic overall digital skills	Eurostat	% of individuals who used internet in the last 3 months	14	57	36.0	9.66	56
DSKILL_MH	Individuals who have basic and above basic overall digital skills	Eurostat	% of individuals who used internet in the last 3 months	44	89	68.4	9.26	56
ECOM_E	Enterprises having received orders via computer mediated networks	Eurostat	% of enterprises	4	32	17.2	6.84	196
ECOM_I	Last online purchase: in the 12 months	Eurostat	% of individuals	0	83	33.9	22.08	353
EDUC_HIGH	Tertiary education (levels 5-8)	Eurostat	% of population (15 to 64 years)	8.7	39.6	23.2	7.42	364
EDUC_MH	Upper, post-secondary and tertiary education (levels 3-8)	Eurostat	% of population (15 to 64 years)	26.0	87.6	70.7	12.73	364
EGOV_G	E-government Index	United Nations	*NA*	51.89	91.93	70.5	10.53	196
EGOV_I	Interaction with public authorities (last 12 months)	Eurostat	% of individuals aged 16 to 74	5	88	43.9	18.52	251
FIX_MPR100	Median price (with line rental) of fixed broadband (speed 100+ Mbps)	EC - Broadband Internet Access Cost	EUR/PPP	24.07	138.45	57.2	28.68	51
FIX_MPR30	Median price (with line rental) of fixed broadband (speed 30-100 Mbps)	EC - Broadband Internet Access Cost	EUR/PPP	15.96	134.75	45.1	19.77	132
FIX_SP100	Fixed subscriptions with 100+ Mbps download speed	EC - Broadband indicators	% of subscriptions	0.00	57.06	9.0	11.62	166

INDICATOR	DEFINITON	SOURCE	UNIT	MIN	MAX	MEAN	SD	OBS
FIX_SP2	Fixed subscriptions with 2 - 30 Mbps download speed	EC - Broadband indicators	% of subscriptions	18.50	99.99	68.7	19.35	165
FIX_SP30	Fixed subscriptions with 30 - 100 Mbps download speed	EC - Broadband indicators	% of subscriptions	0.00	60.06	17.5	14.11	166
FIX_SPNGA	Fixed subscriptions with 24+ Mbps download speed	EC - Broadband indicators	% of subscriptions	0.03	88.39	38.9	22.23	139
FQ_DAILY	Frequency of internet access: daily	Eurostat	% of individuals	4.0	93.0	49.9	19.90	354
GDPBIL	Gross domestic product	Eurostat	billions of EUR	4.8	3132.6	466.6	712.64	364
ISKILL_HIGH	Individuals who have carried out 5 or 6 of the 6 internet related activities	Eurostat	% of individuals who used internet, ever	2	45	14.6	7.44	157
ISKILL_MH	Individuals who have carried out at least 3 of the 6 internet related activities	Eurostat	% of individuals	9	84	52.8	13.36	158
MEDINC	Median income	Eurostat	thousands of EUR	1.38	35.27	13.4	8.01	316
MOB_PENET	Take-up of SIM-cards with mobile broadband	Digital Agenda Scoreboard	subscriptions / 100 people	0.00	147.18	46.3	33.26	252
MOB_PR2000	Price of least expensive offer - 2 000 Mb mobile data package	EC - Mobile Broadband Prices	EUR/PPP	20.21	94.96	43.9	18.99	56
OPER	Number of mobile operators on the market	European Commission	operators	2	8	3.8	1.02	138
SIM_PENET	Take-up of SIM-cards	European Commission	SIM-cards / 100 people	89.60	234.99	134.1	24.10	193
TYPE_ALL	Internet connection type: broadband	Eurostat	% of households	0.0	97.0	55.3	24.72	350
TYPE_FIX	Internet connection type: fixed broadband	Eurostat	% of households	22.0	96.0	64.6	12.65	193
TYPE_FIXO	Household internet connection type: fixed broadband only	Eurostat	% of households	6.0	78.0	48.0	14.00	193
TYPE_MOB	Internet connection type: mobile broadband	Eurostat	% of households	1.0	85.0	23.3	17.66	193
TYPE_MOBO	Internet connection type: mobile broadband only	Eurostat	% of households	0.0	31.0	6.7	6.49	192
U_RURAL	Share of population living in the rural areas	Eurostat	% of inhabitants	0.10	66.60	34.7	16.73	317