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**ANALYSIS OF USAGE OF PUBLIC SECTOR E-SERVICES IN THE EU: CASE
STUDY OF ESTONIA**

Master's Thesis

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ABSTRACT

In a situation where the world is moving towards digitalization and automation of e-services it is vital for service providers to maintain a competitive edge and utilize the full benefits of the circumstances. Much like to the private sector, also the public sector service providers need to think how to engage more individuals and get them to use their services in a more efficient way. For that reason more and more e-services provided by the public sector are designed and created. However, that is only the first step of the challenge and the real difficulties start when these service providers try to get individuals to use those services. Similarly the European Union has a challenge in front of it where more and more Member States are moving towards digital solutions, but face the challenge of engaging their citizens. In addition there is an uneven situation across the European Union as some Member States struggle more and seem to be falling behind. In this research paper, a more in depth analysis is being carried out on the real factors that influence individuals to be more engaged in using e-services provided by the public sector. In order to determine what these influencers are, a theoretical background is set in the first part of the paper. In that part, it is discussed, relying on theoretical data as well as official documents published by various institutions of the European Union, what is perceived to affect the decisions of individuals as well as how the impact is distributed between them. As a result of that, a closer look is taken upon trust, access, digital skills, and knowledge of verification methods as well as socio-demographic circumstances like age, gender and education. In the second part of the research paper, a logistic regression analysis is carried out to measure the impact of and statistical significance of those variables in a situation where the dependent variable is usage of a specific e-service provided by the public sector. In the context of this research paper, the focus is on internet based voting in Estonia as it is a public sector e-service, which because of its nature and significance, requires presumably a higher level of trust and capabilities of individuals. The results are discussed after the analysis is carried out and ideas for further development as well as limitations of the research are evaluated.

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INTRODUCTION AND FIELD OF RESEARCH

Europe is currently on the verge of digital transformation and although the pace each individual country is moving forward varies, the general directions appear to be set and more unified agendas are created. Several regulations have been discussed and are going to be fully implemented during this year or already have been adopted by the Member States. However, not everything is going as smoothly as it seems.

Today, around 14% of the EU population (European Commission, 2017a) have never used the internet, which means it is likely that their lack of contact with services that are provided by the public sector over the internet conclude in lower levels of confidence towards these services. This leads to lower levels of usage and lower probability that these individuals will eventually become end users themselves. However, it is vital, that as many Europeans, as possible, will be engaged in the new setup of economic and social affairs as one of the main challenges today, according to the European Commission, is to maintain the competitive edge of Europe comparing to other markets of the world. (*Ibid*) The key in doing so, is in implementation and usage of e-services across all sectors and regions of the European Union. This means that there is a growing need to engage more citizens as well as other users to become part of this transformation – with the end goal of enhancing user levels.

The objective of this research paper is to rely on statistical analysis in order to see if usage of public sector e-services can be elevated as certain capabilities of people are increased. These factors are digital skills, access, trust, awareness of control mechanisms and socio-demographic characteristics. The first are assumed to have significant impact on usage of public sector e-services and the latter are used to eliminate the chance that sociodemographic characteristics have significant importance, but are disregarded. In addition it is relevant to determine the true impact of socio-demographic characteristics of an individual and analyze the true relevance of those aspects in relation to keeping individuals away from using these channels of public services. It is important to point out that this research paper will focus on public sector e-services and also evaluate the impact of transparency and control mechanisms to public sector e- services. In terms of that, it is

analyzed if these potentially complex verification methods will actually enhance significantly the levels of usage, combined with the increase of actual digital skills and trust towards e-services provided by the public sector. These verification methods could provide a technological solution to a problem in trust, if utilized properly. That will be also measured and analyzed in this research paper. In order to do that, data is taken from questionnaires carried out in Estonia after the elections in 2015 and 2017 and through regression analysis results are being interpreted. It is one of the quintessential public sector e-services, which requires high levels of trust, is internet based voting. Since it is related to the democratic processes that states have, it requires specific attention in terms of implementation and usage. Therefore this paper will evaluate the increase of usage in internet based voting in Estonia and evaluate how access to the internet, digital literacy, trust and knowledge of complex verification methods could enhance the levels of users of a service. It is important to point out that this service was selected to do an analysis which actually reflects the peculiarities that might surface in a situation where services, that demand high levels of trust, provided by the government, are being used by individuals. Additionally this specific service does provide some capability of transparency with individual vote verification and therefore it is possible to evaluate the impact of knowledge of such methods to usage.

The relevance of Estonia comes out as a country, where internet based public sector services have been available since the early 2000's (e-tax declaration since 2000). It is taken as an example because of its high levels of digitalization and being a pioneer in implementing public sector digital services to its residents and citizens. According to the European Commission's Digital Economy and Society index of 2017, Estonia ranks overall on the 9th position in that rating, however, when it comes to the online provision of public services it scores above all other European Union Member States. In addition, as stated by the European Commission, Estonia is "*The champion in Europe*" in providing public sector e-services and scores above average in access to internet and digital skills. (European Commission, 2017)

Not only has Estonia shown good results in the region, but also European biggest economies have understood the need for similar solutions, which has been pointed out by the French Prime Minister Edouard Philippe (Blachère, 2017) with proper tools to tackle excessive bureaucracy (Il Venerdì di Repubblica, 2018) and to bring "*digital*

administration” to other Member States, as pointed out by the former President of the European Parliament, Mr. Schulz in 2017.

The main objective of this research paper is to determine, by using statistical analysis, whether digital skills, trust, access and the presence of control mechanisms are relevant in terms of increasing usage levels of public sector e-services as well as if and how these complex transparency and security adding features, like individual verification, have significant positive impact and explanatory power on levels of usage of those solutions. .

To carry out the main objective of this research paper, the author relies on six hypotheses which are designed to evaluate any role digital skills, access and trust have in terms of usage being increased or decreased. They also intend to evaluate if the assumed aspects that influence usage of e-services are accurate. The empirical part of this paper uses data from Estonia and although there are certain limitations that might redeem the value of some conclusions when using data from one specific state, it is still justified in this specific field of study as it has been pointed out by several institutions that Estonia is a role model in Europe. It is also stated that when it comes to facilitating citizens’ lives and developing digital solutions Estonia is showing highest rankings in the whole of EU (European Commission, 2017a). Especially in a situation where digital skills are vital to raise personal competitiveness and usage of e-services the lack of them could affect severely around 170 million people (*Ibid*), or 44% of adult Europeans.

This research paper is divided into three main paragraphs where the first one focuses on setting the proper theoretical background and introducing current trends in usage of public sector e-services across Europe. It also takes into account current contemporary processes as well as the situation across the European Union. Furthermore, since trust appears to be an integral part of the usage of digital services, the analysis will evaluate if trust actually does play such a part, or perhaps is usage related more to the digital skills, access to the system and knowledge of verification methods. The second paragraph focuses on the methodology of statistical analysis and data collection. In that paragraph, the empirical analysis is carried out as well as the usage of data and transforming some variables will be explained. The third paragraph focusses on discussion following the empirical findings.

The data that is used in this research originates from questionnaires carried out during elections in Estonia and is gathered over a time period of 5 years. In order to carry out statistical analysis, IBM SPSS is being used. In addition other methods and tools of statistical analysis are being utilized in order to get more thorough results, such as MS Excel.

The results of this analysis will be valuable not only for service designers, security engineers and the Estonian National Electoral Committee, but to a much wider audience on the institutional level of the European Union as well as in its unique Member States. That, of course, gives the opportunity to perhaps increase the level of digital skills, access and trust, as well as usage levels across the European Union and therefore also tackle the challenges Europe faces in this area.

DEFINITIONS

QR- code – A QR- code is the abbreviation for quick response code, which was first developed in Japan in 1994 by Denso Wave Incorporated and can be used as a machine-readable optical label with information associated to an item or product. Thanks to its two directional information coding ability, it can be read easily by a QR code reader or a smart device with a camera and it is capable of holding a great deal of information. (Chang, 2014)

Smart device – a smart device can be defined as an easy-to-use personalized device through which information can be obtained anytime and anywhere through connection to a wired or wireless network. (Lee, 2013)

E-Services – short for electronic service, is a general term that refers to services over the information-communication technologies. The term e-service has many applications and can be found in several disciplines, out of which the two main application areas are e-business (e-commerce) and e-government. (Kvasnicova et al., 2016)

eIDAS – is the European Regulation for the electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC. It aims to improve trust in EU-wide electronic transactions and to increase the effectiveness of public and private online services and e-commerce. (Official Journal of the European Union, 2014)

GDPR – is the European Regulation that allows European Union citizens to better control their personal data. It also modernizes and rules allowing businesses to reduce red tape and to benefit from greater customer trust. It is part of the European Union data protection reform package. (Official Journal of the European Union, 2016)

1. DIGITAL TRANSFORMATION AND CHALLENGES IN THE EUROPEAN UNION

The European Union is currently on a verge of going through a digital transformation where increasing amounts of e-services are being developed and the challenges imposed by this change are getting increasingly evident. According to the European Commission, this transformation enables to present enormous growth potential to several fields and it's strong presence in traditional sectors should benefit the whole Union greatly, if all parties can actually seize the opportunities in front of them (European Commission, 2018b). The Commission also points out the vital need to enhance digital skills of individuals as it plays a significant role in the transformation process and is therefore a major priority for Europe. In addition there is a strong need to establish ICT standards, which play an essential role in achieving interoperability of new technologies and serve as another potentially significant landmark to benefit industries, as well as end consumers (European Commission, 2018d).

This topic is part of the main future priorities in the EU. In May 2015, the European Commission adopted a Digital Single Market (DSM) strategy as one of its top ten priorities for 2015 to 2019 (European Commission, 2018g) with sixteen initiatives which should encompass three broader topics: promoting better online access to goods and services across Europe; designing an optimal environment for digital networks and services to develop and; ensuring that the European economy and industry takes full advantage of the digital economy as a potential driver for growth. (European Commission, 2018c)

Several attempts have been made to move forward with legislative measures to impact these changes, such as adoption and implementation of the Regulation (EU) 2016/679 of the European Parliament and of the Council, otherwise known as the General Data Protection Regulation (GDPR) in May 2018. (European Parliament, 2016). That is a clear indicator towards the current digital transformation, which attempts to regulate data management and processing as well as generate trust towards a unified framework. Trust being here the key word, has been pointed out to be an integral part of increasing the

usage of e-services. Furthermore, there is also a clear acknowledgement on the importance of creating trust, which will help the digital economy to develop.

Additionally the Regulation (EU) No 910/2014 on electronic identification and trust services for electronic transactions in the internal market (eIDAS Regulation) adopted on 23rd of July in 2014 with, amongst other things, the aim to enhance trust in electronic transactions in order to provide a common and secure foundation for electronic interaction between citizens, businesses and public authorities, plays a substantial role in designing the future of e-services in Europe. These changes are driven by the need to increase effectiveness of public and private services and generate trust through common framework. This understanding towards a need of change has been around already for several years with the aim to develop and implement measures, which should transform Europe into a more trusted and secure online environment with an opportunity to give citizens and businesses a capability to fully utilize the benefits of a digital economy (European Commission, 2014). However, it is not sufficient to build a common framework rather than to also engage actual users and get them utilizing the benefits of these solutions. As trust itself has been pointed out to be a characteristic of great importance, in the following paragraphs a specific focus is put on trust. In addition other characteristics are under examination, but trust has a stronger focus in the context of this research paper.

It is also pointed out that the benefits of digital transformation and movement towards a fully realized DSM would have significant potential for economic growth across the EU with up to 3.8 million new jobs, which could be created and an increase of 6% of gross domestic product (GDP) (Strategic Policy Forum on Digital Entrepreneurship, 2016).

As further, not only EU institutions have realized that there is a need to increase digital skills of individuals, some of the political forces have understood similar needs and are pointing out in their future agendas and visions that it is vital to work on ensuring that citizens do have adequate skills to thrive in the digital economy, with access to education and training being a priority. (European People's Party, 2017) This means that in addition to trust, digital skills are also becoming a significant contributor to bring individuals closer to e-services provided by the public sector.

In the next paragraph of this research a closer look is taken upon the current state of the European Union in the context of digitalization.

1.1. Current state of digitalization in the EU

Having determined that one of the main challenges of digital engagement and development is linked directly to trust and the current situation in the EU is somewhat lacking in that field, it is absolutely vital to find a way to increase trust towards public sector e-services and to get more Europeans engaged in democratic processes.

Before a closer look can be taken towards the links between digital skills, trust and usage, it is vital to evaluate the current state in the EU. It is clear that with an overall population of around 500 million people, some are bound to have better access to digital tools, such as a computer or internet connection and this can severely affect the overall levels of inclusion when it comes to the ability to use public sector e-services.

However, according to a Euro-barometer (European Commission, 2017b) survey carried out between March and May 2017, the results indicate that the overall opinion of having the necessary skills to be engaged is rather high. It is also pointed out that the majority of respondents evaluate their skills as sufficient in a range of life and work, however, there are significant differences when it comes to evaluating the same things across different member states. It is also vital to point out at this point, that the survey is conducted in a manner where respondents need to give a self-evaluation and therefore the results could possibly suffer the impact of subjectivism. Therefore these could be visualized as perceived skills which because of their specifics, could differ from actual skills. In order to find a solution to the issue of not having enough individuals using public sector e-services, a closer look will be taken to several variables, which could affect the true skills of individuals.

Furthermore the differences do not only present themselves in different member states, but also in different socio-demographic groups, with education and age being the primary influencers. As visualized in the following figure (See Figure 1.), a total of 71% of respondents consider themselves having sufficient digital skills to tackle digital technology in their daily lives.

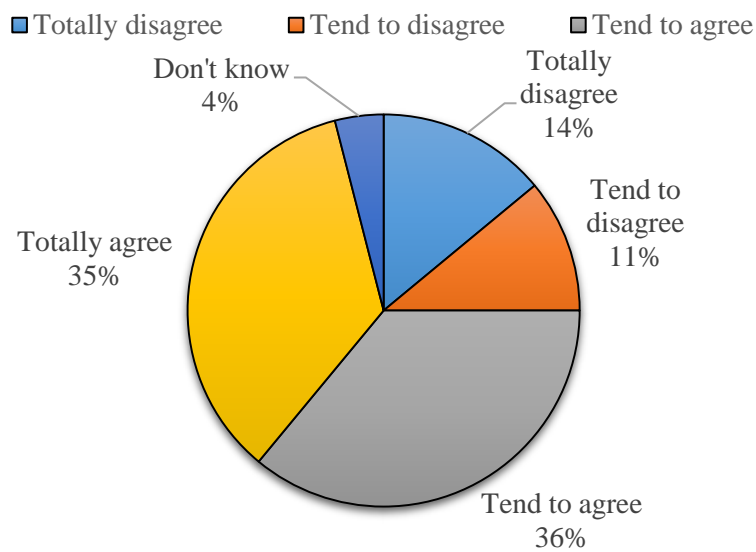


Figure 1. To what extent do you agree or disagree with the following statements regarding your skills in the use of digital technologies: You consider yourself to be sufficiently skilled in the use of digital technologies in your daily life (% , EU-28) Source: European Commission, 2017b

This of course gives the indication of the EU average. However if a closer look is taken on the results of specific Member States, then in four occasions less than half of the respondents felt that their capabilities are sufficient to use e-services in their daily life. Those countries are Hungary (45%), Bulgaria (47%), Greece (47%) and Slovakia (48%). At the same time, the respondents in Estonia found that 74 percent of them had sufficient skills to use digital technologies in their lives. (European Commission, 2017b)

In addition, if the same question is asked about the ability to use public sector e-services, such as filing a tax declaration or applying for a visa, the result has dropped to 65%, which in itself is not a remarkably lower result, but given the gravity and importance of skills in order to guarantee digital inclusion, it is still a trend that could have long term negative impact in terms of implementing the goals of digital inclusion in public sector e-services. As pointed out in the following figure (see Figure 2.), the amount of people who doubt their ability to successfully use these services has increased to a total of 30%.

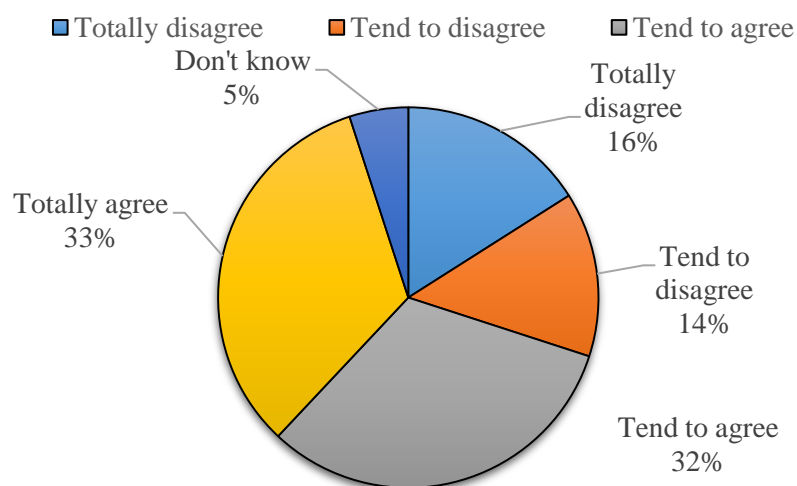


Figure 2. To what extent do you agree or disagree with the following statements regarding your skills in the use of digital technologies: You consider yourself to be sufficiently skilled in the use of digital technologies to use online public services, such as filing a tax declaration or applying for a visa online (% , EU-28) Source: European Commission, 2017b

Although these results might appear not to have exceptionally drastic outcomes, if a closer look is taken towards the bottom half of the Member States, then it is clear, that the capability to use public sector e-services is uneven across the European Union. In this case not only Slovakia (48%), Bulgaria (47%), Greece (47%) and Hungary (45%) have a low level of individuals that assess their skills to use public e-services sufficient, but also economic powers like Germany (65%), France (64%), Belgium (62%), Spain (60%) and Italy (57%) have results below the EU average of 65 percent. (European Commission, 2017b)

At the same time, the overall position towards digitalization in the EU is positive and respondents across the EU believe that digital technologies could impact the society, but also their quality of life and the economy as a whole positively. (*Ibid*) Therefore people recognize the need to move towards digital solutions, but assess their own capabilities to be unsatisfactory to take full benefits.

Another research carried out in the United Kingdom across young individuals aged 16-25 suggests, that 84% of all respondents believe digital literacy (or skills) being important in their place of business. With the EU working strongly on lifelong learning and keeping

people longer active at the labor market (European Commission, 2018f), this opinion would have a spill-over effect in other age groups as well.

In addition to having necessary skills to enhance one's personal life, the Cybersecurity Strategy of the European Union, adopted in 2013 suggests that it is also vital to have trust and confidence in order to utilize the benefits of e-services, such as e-payments, machine-to-machine communication or cloud computing. It is also suggested, that according to studies carried out, this transformation could possibly boost EU's overall GDP by almost €500 billion a year, which is an average of €1000 per person. (European Commission, 2018a)

As there is a significant potential impact in utilizing the benefits of digitalization and increasing the amount of individuals using the internet, as well as public sector e-services, the overall trends seem to be positive. In the following figure (See Figure 3) it is visible how the amount of individuals who have not participated in any actions over the internet has been gradually decreasing over the past decade.

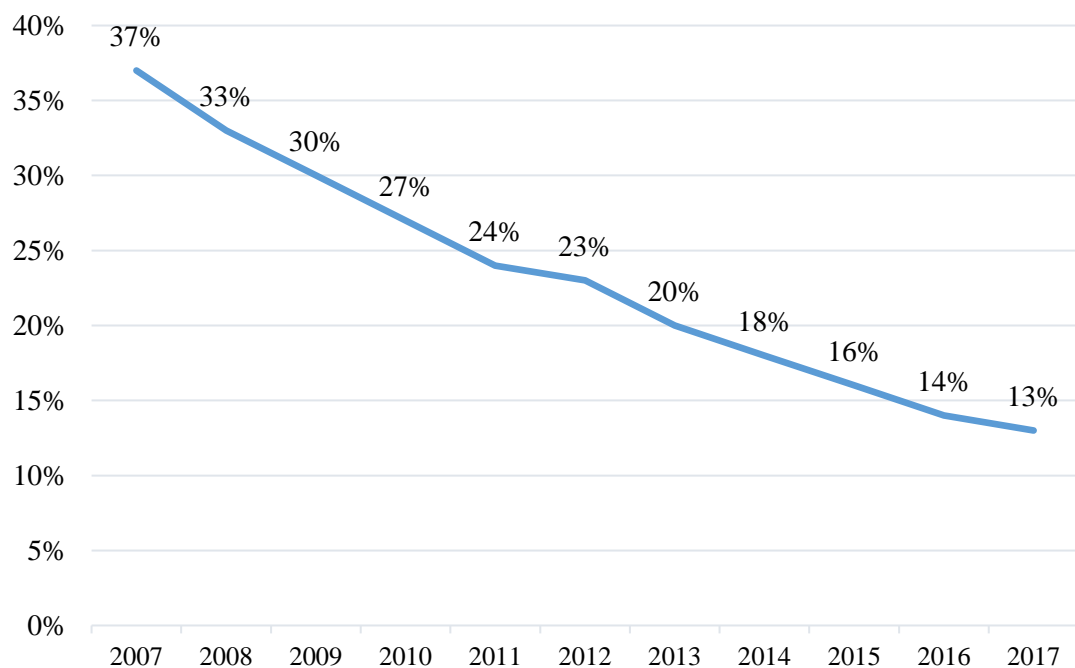


Figure 3. Individuals who have never used the internet (EU-28), 2007-2017, (% of individuals). Source: Eurostat, 2017.

Although it is clear that the overall number of individuals that have never used the internet is decreasing, it doesn't automatically suggest that all of those individuals are using internet for the purposes that are contributing to the long term goals of the European

Union. Additionally, as the levels of skills that individuals have in certain Member States are lower than expected, these trends pointed out on the previous figure (Figure 3.) might suggest that individuals are engaging more and more in activities on the internet, but are not doing so in e-services that are provided by the public sector.

In addition to usage of internet, skills themselves are not sufficient to have long term wider impact on usage of services and trust levels. As suggested in the Copenhagen Report of 2010, it is assumed that infrastructure, or in other words, access to the internet, and digital skills, are equally important and that the combined effect of those two variables could affect the use of online services 3% per year. It is also suggested, that one of the barriers of having a truly Digital Single Market, is still the lack of trust in the internet. (Copenhagen Economics, 2010)

Therefore, it is possible to state, that in order to implement strategies, which would lead to a truly Digital Single Market and get more individuals using e-services provided by the public sector, it is not only necessary to enhance personal digital literacy levels and improve access to the internet, but also to increase the trust towards these very services.

This gives already an indication, that if these challenges could be solved, it would be much easier to benefit from a more interoperable and free digital economy across all Member States. As pointed out previously, one of the main challenges in terms of engaging people, is the lack of trust and therefore it has been pointed out on several occasions by the Vice-President of the European Commission Andrus Ansip, that not only are privacy and protection fundamental to the Digital Single Market, but in addition, one of the most pressing challenges in the DSM project is to create an online environment which people can really trust, adding that without trust, people will not use e-services (Ansip, 2017).

This gives an indication that digital skills, access to internet, usage of services and trust might be connected and if there would be the ability to increase some of the variables, others would perhaps increase as well. As trust has been pointed out separately from other variables that could change the levels of individuals using e-services provided by the public sector, the assumed relations between digital skills, trust and usage are visualized in the following figure (See Figure 4).

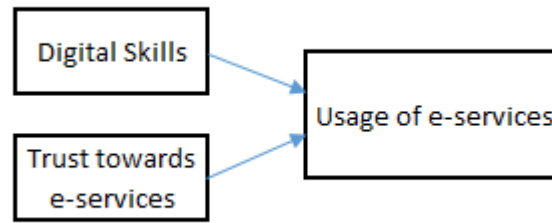


Figure 4. Relation between digital skills, trust and usage of e-services. By the author.

In the following paragraph a closer look is taken upon trust itself as an integral part of getting individuals using public sector e-services. This paragraph includes also deeper understanding of digital skills as well as levels of trust towards e-services across the European Union. Additionally some data from Estonia is added in order to verify the possibility of using Estonia as an example to carry out the research. After that it is possible to move towards the empirical analysis and carry on according to the steps determined previously.

1.2.Characteristics of trust and digital skills that affect usage of e-services in the EU

1.2.1. Definitions of Trust

Trust itself is something that cannot be forced, however, there might be ways to enhance the levels of trust. Currently the EU has around 33% of its citizen's buying (Eurostat, 2017) merchandise from another member state and one of the reasons behind this low number is mainly related to the lack of trust. (*Ibid*) Although this is a service that is not predominantly provided by the public sector, the indications that it gives are transferrable to public sector e-services as well. Before any further steps are taken, it is important to clarify what trust is, how it could be perceived and how the definition of it can indeed vary in alternative surroundings. In the context of this research paper, trust is visualized as one of the main independent variables that affects overall levels of usage of e-services and will be taken a closer look upon.

According to Lynne G. Zucker: "From a sociological perspective, trust is defined as a set of expectations shared by those involved in an exchange." (Zucker, 1985, pp 2) However, it is also added that trust being self-evident in most transactions, its nature is complicated

to capture, or in other terms – difficult to measure. There is also a suggestion that trust, provided by transparent regulations and solid institutions leads to feelings of relative security in a person that the outcome of a situation or endeavor will be favorable to that person (Harrison-McKnight & Chervany, 2001). This relative security could perhaps be turned into real security when transparent control mechanisms are being implemented. Therefore in the context of this research paper vote verification is being used as one of the dependent variables which could affect the usage levels of e-services. When it comes to the EU and its member states, it is important to take a look at more organizational level and then it can be pointed out, that trust has emerged as a central strategic asset for an organization (Mayer et al, 1995) as well as on how we interact with others (Berscheid, 1994). In fact, as pointed out by other authors, trust can be defined as the willingness to be vulnerable to the actions of others in a situation where there is valid expectation that those others will carry out the action, regardless of the lack of ability to verify if it actually was carried out the way originally intended. (Mayer et al, 1995) In this case, the others would be an institution which is providing services to individuals via digital channels. The question here lies, what would happen if the trustor would get the ability to carry out an independent process where he or she could actually verify the fact that the trustee has indeed delivered to the extent that had been agreed upon earlier.

In the context of this research paper, it is observed alongside with trust, whether better knowledge about these control mechanisms actually influence levels of usage of e-services and if they do, then whether this is a positive or negative effect.

Furthermore, as it has been pointed out by several researchers, there is no universal definition in trust and different authors have their own interpretations. That being said, those researchers often mix different components, such as risks, uncertainty, quality, competence, reliability, dependence, honesty, sincerity, security, etc. together (Müller et al, 2003).

As we take a closer look on how to measure trust, it is clear, that the actual components of measuring or affecting trust can be somewhat difficult to pinpoint. However, in terms of this thesis, it is not necessary to exactly define trust, rather than to give an overview of the undefined concept of it, nor evaluate or measure trust, rather than find out how certain variables, including trust, which could be influenced, can have a positive effect on usage

of public sector e-services and through that, a greater socio-economic impact to the EU as a whole.

1.2.2. Aspects that affect usage of e-services

In the context of this research paper, it is however important, to seek the attributes that might affect usage of e-services. It has been pointed out by KPMG that organizations, which aim to increase digital trust, should focus on reliability, credibility, transparency, security and integrity (KPMG, 2015). It is also pointed out that accessibility still remains as an important feature in building trust towards your services. That being said, as trust levels increase, usage levels should raise as well and individuals should be able to access the service when it suits them. Also pointed out by the UK Government, in order to guarantee digital inclusion, organizations need to be aware not to make circumstances complicated for the users (Cabinet Office, 2014). Therefore it can be established that in addition to trust, access is one of the other important key aspects on providing digital inclusion and through that also usage of public sector e-services. In addition, through research and consultation it has been established that the main kinds of challenges people face to going online are (Ibid, 2014):

- Access – the ability to go online and/or connect to the internet
- Skills – to be able to use the internet (digital literacy)
- Motivation – knowing the reasons why using the internet could be beneficial
- Trust – fear of negative outcomes, not knowing where to start

In the context of this research paper, the author excludes motivation, as an internal variable which could differ greatly in case of various individuals and perhaps not provide measurable outcomes. Especially as motivation could be affected by a number of individual circumstances. Trust, like access and skills are visualized as independent factors in later parts of this research paper and a closer look is taken upon these factors. Specifics of these factors, will be focused in paragraph 2, which leads the way to empirical analysis, but in the beginning focuses on methodology and data.

According to surveys carried out in the EU by Eurostat, the amount of individuals using the internet on a daily basis is on the increase. There is still a significant divide between member states, as well as a gap in age but these trends are decreasing. The following

graph shows how daily usage of internet differentiates in EU member states population by age.

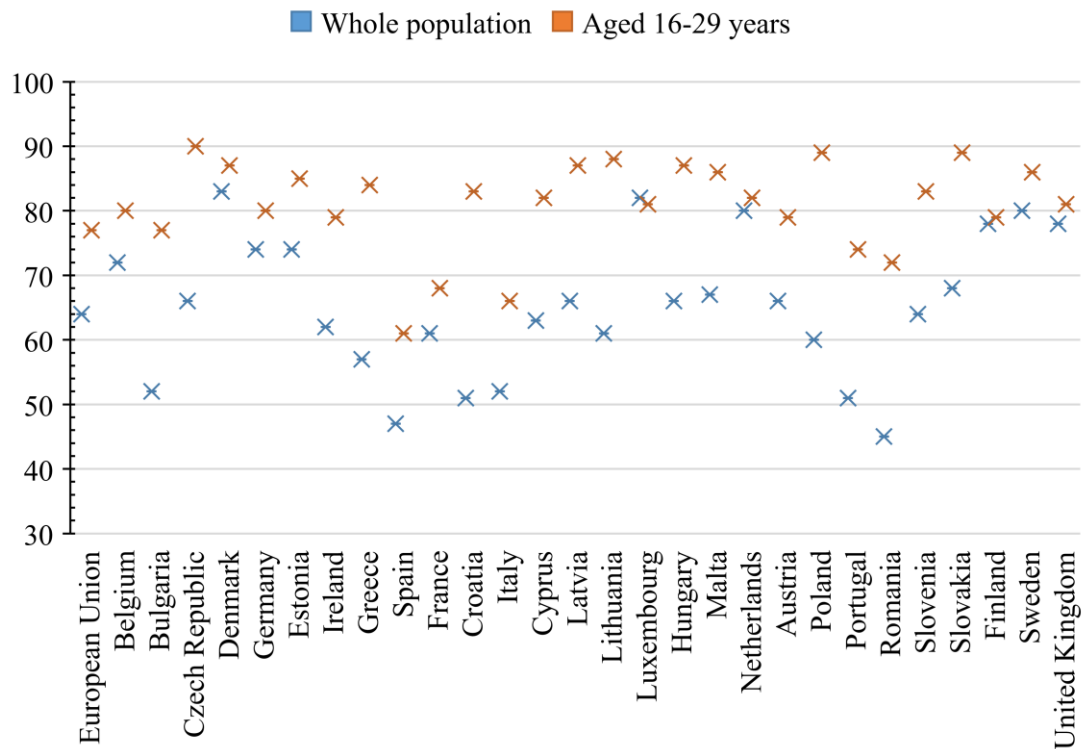


Figure 5. People who used the internet on a daily basis, 2017 (% of population). Source: Eurostat, 2017.

Although this suggests that younger individuals are more active than individuals with a higher age, it doesn't specify the reasons behind it. It is clear that age is a significant contributor to an individual's activity in terms of internet usage, but it is not necessarily the reason that actually affects usage. It could well be, that age itself as a consequence acts as a proxy to the real influencer, which could be concluded with a common denominator as digital skills. Therefore that aspect, as well as other socio-demographic aspects will be included to the empirical research. In addition there are several characteristics, which are included by various researchers that have an impact on usage of e-services and inequality in the information society. As brought out by Verdegem and Verhoest, the following characteristics are also claimed to have influence in terms of digital inclusion (Verdegem & Verhoest, 2008):

- Gender - these differences are evident however at the same time declining in access and basic levels of engagement
- Age – as one of the most important dimensions of ICT inequality, it is connected to limited modes of use as well as patterns of connecting
- Education – lower levels of education are related to issues with access as well as usage variations
- Family structure – it is suggested that the presence of school-age children in a household tends to increase contacts with ICT
- Additional variables – such as race, location, social participation and others might also determine access and usage of ICT

Although it is clear that all of those aspects could be used to categorize individuals into different groups of ICT and/or e-service usage as well as trust and skills, but in the context of this research they are assumed to be as proxy variables which represent certain groups, however are not the cause. Regardless, some of those variables, like gender, age and education will still be taken into account as the empirical research is being carried out.

Furthermore, in this research paper the emphasize is put on variables that can be changed and are assumed to have a direct impact on usage, such as trust, digital skills, access to internet, access to devices etc. However, some of the socio-demographic variables will also be added to the analysis in order to eliminate the possibility that they actually do affect the results in a statistically significant way and that they are not assessed. In the second part of this research, these variables are inspected and justified more closely.

If operated under the assumption that trust is higher in individuals who have more experience (usage) and exposure to e-services, it is possible to determine how different variables could affect the levels of usage of public sector e-services and perhaps also by how much. It is clear that the usage of internet as well as utilizing the benefits of e-commerce or other e-services has increased gradually during the last decade and although certain socio-demographic groups are not as active as others, the increase is still significant. That being stated, it is also important to differentiate between e-commerce and public sector e-services that tend to demand higher levels of trust and skills than private sector services. On the following figure (See Figure 6.) we can see that in the age group 25-54 and 16-24, the usage of e-services for personal need is significantly higher

today as in the age group 55-74. At the same time it seems that there has been a significant increase specifically in the younger age group, which could be explained by the introduction and spread of smart devices such as smart phones and tablets during the past decade.

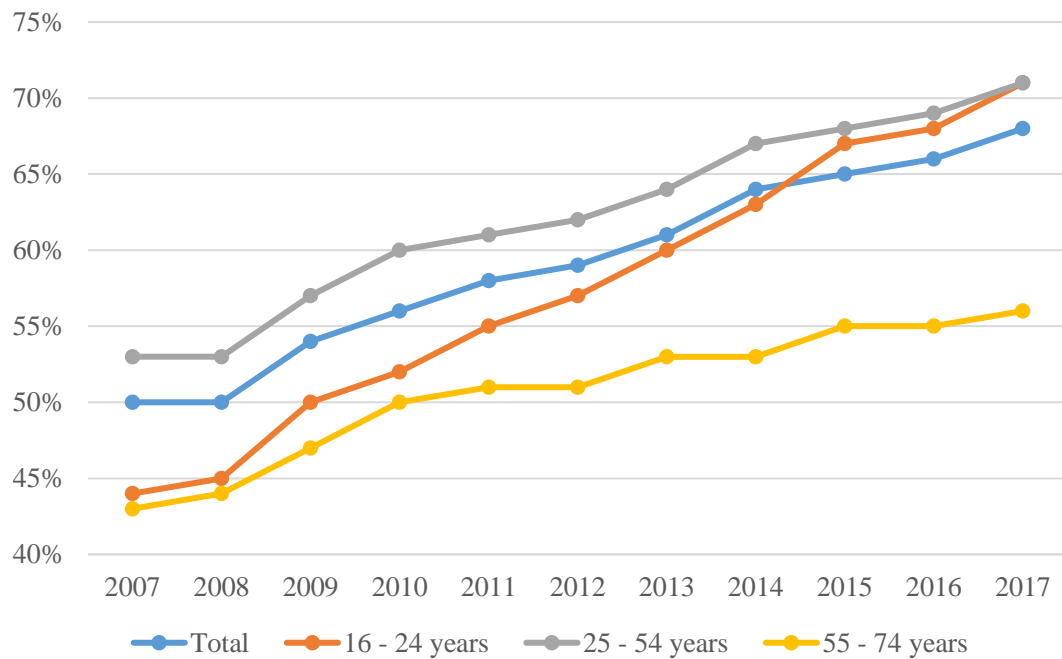


Figure 6. Internet user who bought or ordered goods or services for private use in the previous 12 months by age group (EU-28), % of internet users. Source: Eurostat, 2017.

In addition, it is also important in terms of fulfilling the objectives of this research, to evaluate how the aspect of access has changed over time and operating under the assumption that access is also something, which in long run could affect the overall usage levels because of giving people the ability to explore the options calmly at their own time and in the comfort of their own home, we can see that this too has changed significantly over the past years. For example, the average internet access at households has increased from 2007 until 2017 approximately 32 percent, reaching 87 percent on average by 2017 (Eurostat). In this context the term “internet access” refers to the possibility of anyone from a household being able to access internet from home and does not refer to the connections that can be made in the household’s area or street (*Ibid*), therefore even if people do also have a place to go and use the internet which is publicly provided, like a local municipality building or public library, this tackles the issue of having internet access at home.

From the following figure (See Figure 7.) it can be seen that although there has been some significant increase in the last couple of years, the results still vary greatly in different member states and regions.

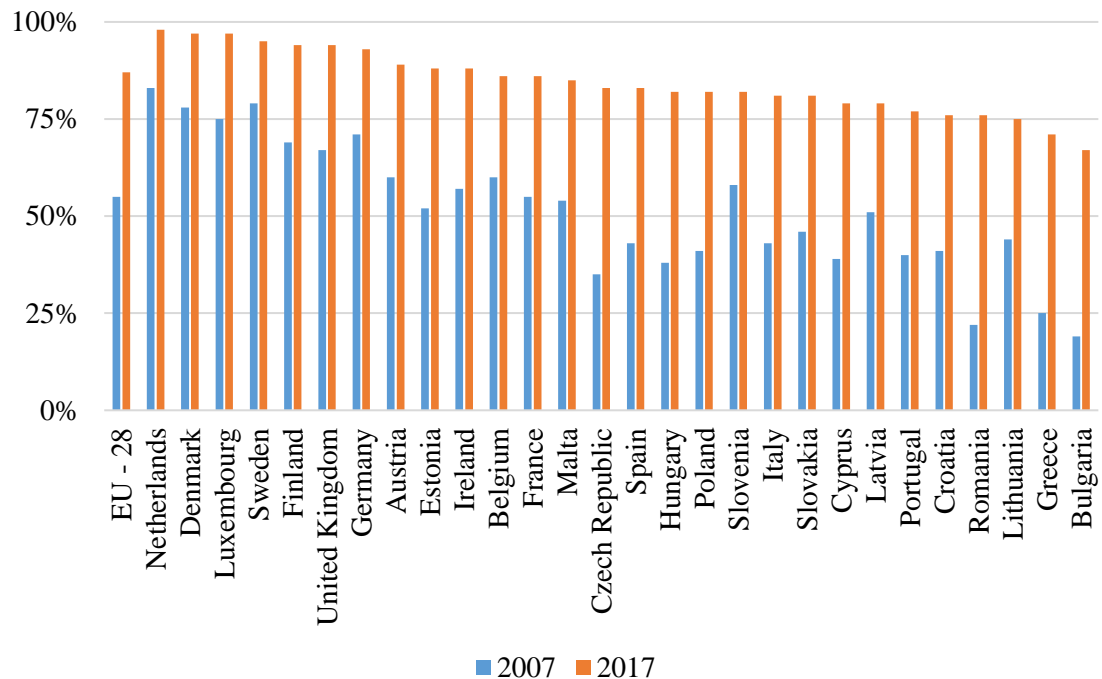


Figure 7. Internet access of households, 2011 and 2016 (% of all households) Source: Eurostat, 2017.

Another significant change in the last couple of years has been the decrease of computer usage in the population. Although again, as with other characteristics it varies to member state and also in different age groups by the size of the impact, it is clear that new methods of internet access are gaining users. In the following figure (See Figure 8.) it is visible how the usage of smartphones is exceeding the usage of any other type of devices significantly with some changes in age groups. It is also visible that the device of choice is no longer the desktop computer nor a tablet computer, rather than a laptop and a smartphone.

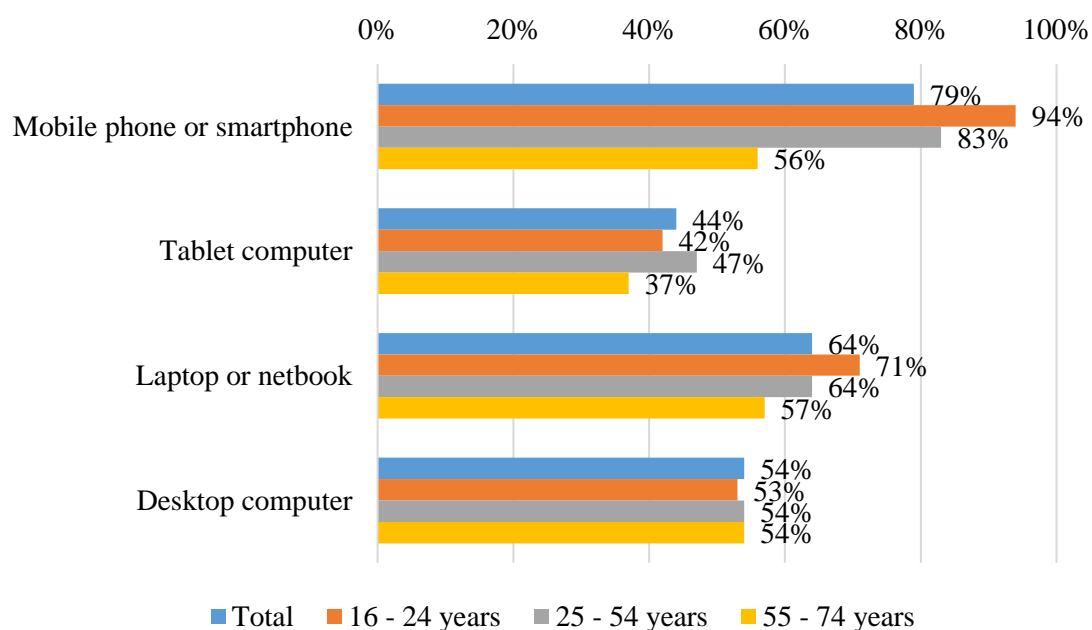


Figure 8. Main devices used in the EU to surf the internet, by age groups, 2016 (% of internet users over the last three months). Source: Eurostat, 2017.

Those trends indicate that in order to determine whether or not usage of devices and/or access to devices could affect usage of e-services provided by the public sector, it is vital to measure the most popular devices. In order to do so, the usage of desktop computers will be disregarded in this research paper and the focus, in terms of devices, will be towards newer and more popular solutions. However, as the current trends of usage of e-services across the European Union have been clarified, it is necessary to move towards the levels of trust and later assess how usage and trust could affect usage.

Since the data that is going to be used will be coming from surveys carried out in Estonia, it is important to have a closer look on how Estonia is being positioned in terms of skills, access, trust and other aspects that might influence usage of public sector e-services. In order to do so, in the next paragraph, some of that information is evaluated and after that, the empirical research can be carried out in the following paragraphs.

1.3. Trust and usage of public sector e-services in Estonia

Although different countries have achieved rather high levels of engagement in terms of citizens using public sector e-services, others are still significantly lacking behind. In the context of this research, it is necessary to bring out the specifics of Estonia and why its experience in digital transformation could be used as a potential role model for others. It

is clear that not all e-services are the same and there is significant difference in services which are provided by the private sector to those, which are provided by the public sector. In the transition of the EU and its Member States, in becoming a more inclusive service provider, a closer look is taken upon e-services that are provided by the public sector. For example, in Estonia 78% of the population have used the internet for interacting with the public authorities. That is not the highest of the EU, but still significantly higher than the average of 49%. However, if a closer look is taken upon the actual interactions it turns out that on average 30% of individuals in the EU have downloaded official forms from the internet, whereas the same number in Estonia is 40%. This of course is not very high and is much lower than in some other EU member states like Luxembourg with 65% and Denmark 51%, but can be explained by the fact that in many cases it is not necessary to download a form in Estonia in order to submit it.

Furthermore, the forms themselves are quite often pre-filled and therefore it is more accurate to take a look on the number of individuals that have actually submitted a form over the internet. This already reveals a much more adequate picture of the current situation where the average of the EU remains at 30%, but Estonia is at 70%. In addition, it as Denmark also does well at around 71%, but Luxembourg is now only at 36%. Although it is clear that in Denmark, much like Estonia, e-services are being actively used by individuals, the focus of this research entitles to look at Estonia, as it is continuously the highest ranking public sector e-service provider in the EU, in comparison to Denmark, which in that ranking is at position 4 (European Commission, 2017c). Another important aspect is that Estonia as such seems to have a more all-encompassing framework of public sector e-services, where other countries are excelling in only specific sectors.

Additionally, Estonia, as a state, is considered to be a global leader in public sector e-services and e-voting with high user numbers across all socioeconomic groups. (Digital Dividends 2016, 168) Moreover, in the same document Estonia is considered to be one of a handful of countries closest to a digital society, and although a lot of countries have also eagerly invested in digital technologies, they have not succeeded in creating an environment to support development in that field (*Ibid*). Therefore it is fundamentally important not to take a look at countries that have been invested into certain technological aspects rather than to look towards examples where actual results can be seen.

In the next paragraph the focus will be on empirical research and carrying out the statistical analysis in order to determine whether the research question and purpose could be answered. In order to do so, a closer look is taken on six hypotheses in order to measure and analysis to which extent different factors of daily proceedings and habits could affect individual levels of usage of e-services provided by the public sector. However, before a closer look will be taken upon the data itself and analysis, it is necessary to clarify the usage of different factors and variables

2. EMPIRICAL RESEARCH AND CASE STUDY OF ESTONIA

2.1. Purpose of the research, hypothesis and research questions

The main purpose of this research paper is to determine how different variables could affect people's usage of public sector e-services if the socio-demographic characteristics are removed. In order to do so, the research relies on six hypotheses designed to bring out correlation and dependencies between user behavior, access, knowledge and trust in relation to usage. As discussed in the previous paragraph, trust itself can have a variation of definitions, however it is still concluded that in order to create a relationship between the trustor and trustee, certain influencers might change the very essence of that relationship. In order to see if states could be able to affect the transition rates from distrust or indifference towards usage of services, some specific variables are being used. In this research ten different variables are being examined in order to determine the outcome. Also, as discussed before, this research will focus on non-socio-demographic characteristics of individuals, such as independent behavioral patterns.

There are also some modifications that have been done to the variables and they will be discussed in this paragraph. One important aspect is that all individuals that did not know an answer or did refuse to give an answer have been eliminated from the dataset. The other modifications will be discussed at the respective variables.

The specific variables being used in this paper are following:

- Digital skills

The author will operate under the assumption that better knowledge of a certain system or capabilities to conveniently orientate oneself in an environment will increase positive impact on usage, as an individual becomes more familiar with the risks involved and also grows a better understanding of the environment itself. That being said, it is assumed that if a person would have higher digital skills, then person would use the capabilities of the digital world a greater deal, which in return would mean, that states, or any other interested parties, would be able to endorse digital skills to increase usage of their services.

This variable is used in order to evaluate a person's skills that are not only related to a modern smart device, rather than evaluate if that person has any skills, which might be

related to a technology and/or access point which has been around for a longer period of time and therefore giving that individual the opportunity to get acquainted to that method and have real life experience.

Additionally, it is necessary to point out that this variable relies on the personal opinion of the individual who provided the answer and the answers of the question: “How do you evaluate your computer skills? Are they:”, have a variety of predetermined values: “Very good”, “Good”, “Average”, “Basic”, and “No computer skills”, “Refusal” and “Don’t know”. The variable itself is coded into two dummy variables in which the first one assesses good skills and the other one average skills. This will enable to take basic or no skills as a reference and evaluate how levels of PC literacy affects usage afterwards. The coding is done as presented in the following table (Table 1.):

Table 1. Binary coding of the Digital Skills variable.

Original value	PCliteracyDummyGoodSkills	PCliteracyDummyAverageSkills
1 Very good	1	0
2 Good	1	0
3 Average	0	1
4 Basic	0	0
5 No Skills	0	0

This enables to view individuals with “Very good” skills and “Good” skills as one and “Average” skills as one and leave “Basic” skills as well as “No skills” as a reference.

- Access to a smart device (smartphone or tablet)

Another vital aspect of usage of e-services is having a point of access, or in other words, a device to use in order to be connected to the digital world. Another alternative would be to measure a person’s access to a computer, however, given the recent trends in the past decade (pointed out in the first paragraph), it is evident that smart devices are gaining more penetration when it comes to browsing the internet (Hern, 2015). Taking this into

account, in addition to the assumption that it would provide more accurate information about accessibility to the digital world, this research focuses on smart devices.

This variable is being used in order to determine whether a person would have the possibility to access the internet and therefore also various trust adding features like end-to-end verifiability by determining if that individual has access to a smart device. The question to be answered by the respondents was the following: “Do you have access to a smartphone or tablet?” and the possible answers were: “Yes, smartphone”, “Yes, tablet”, “Yes, smartphone and tablet”, “No”, “Refusal” and “Don’t know”. This variable is transformed to have binary values with access to smartphone and/or tablet as one answer and no access as another answer, presented in the following table (Table 2.):

Table 2. Binary coding of the Access to smart device variable.

Original value	AccessToSmartOrTabletDummy
1 Yes, smartphone	1
2 Yes, tablet	1
3 Yes, smartphone and tablet	1
4 No	0

This will enable to evaluate if people have access or they don’t have access rather than evaluating to which type of smart device they have access to. In this research paper, it is not relevant to differentiate the specifics of a smart device.

- Internet usage (days per week)

Additionally, having skills and a smart device is insufficient if they are not or cannot be utilized. Therefore the author also takes into account actual usage of the internet over a week’s period of time and the assumption would be that the more a person uses the internet, the better they feel in that specific environment and are therefore also more likely to have trust towards this environment. It is also suggested that using the internet at a more frequent rate would mean that the individual will find more data to be able to form educated opinions on the security of a service and also on the quality of different services.

This variable is intended to evaluate the usage of internet by an individual over a time span of one week whilst carrying out their regular behavior patterns which shouldn't be affected by any specific circumstances (like the annual date of filing personal income tax declaration) rather than to evaluate their own assessment of the frequency of using the internet in their weekly proceedings. The question to which the respondents answered was the following: "On how many days over the last week have you used the internet, for example surfed on the World Wide Web, sent an e-mail or used e-banking?" and the answers to this variable could be selected from a pre-determined set which is according to the number of days in a week a person uses internet, from 0 to 7, accompanied by the options "Refusal" and "Don't know". Much like the previous variable, in this case the results were transformed into binary results, presented in the following table (Table 3.):

Table 3. Binary coding of the Internet usage variable.

Original value	InternetUsageDummy
0 0	0
1 1	0
2 2	0
3 3	1
4 4	1
5 5	1
6 6	1
7 7	1

This enables to see how low levels of usage might affect the outcome compared to average and higher than average levels of usage. In terms of this research, it is not necessary to determine how much one added day of usage of internet affects the usage of public sector e-services rather than to determine how active users are compared to non-active users.

- Quick response (QR) code usage (has used QR-code)

The following variable is intended to be used to determine the ability to utilize the benefits of a complex assurance system, such as vote verification and therefore perhaps have higher usage levels in system as a whole. However, QR code usage is separate from other digital skills and used at a later stage of this analysis, since it is not relevant to contribute to the ability to access the internet and use services, rather than it is a method of providing confirmation in an occasion where the sequence of events has followed the intended path. Therefore it is included to evaluate if actual experience by the respondent to utilize the benefits of using a QR-code in order to provide more transparency to an action and therefore perhaps also increase usage of a specific service.

The question asked from the respondents was: “Have you ever used a QR code?” and the possible pre-determined answers were the following: “Yes, many times”, “Yes, sometimes”, “Never”, “Don’t know QR-code”, “Refusal”, “Don’t know”. This variable has been changed to differentiate between people that have user experience with QR codes and the ones that do not have user experience or knowledge at all, as presented in the following table (Table 4.):

Table 4. Binary coding of the QR code usage variable.

Original value	HasUsedQRDummy
1 Yes, many times	1
2 Yes, sometimes	1
3 Never	0
4 Don’t know QR code	0

This enables to evaluate the impact of individuals that have experience to the individuals that have no experience. As with previous variables, it is not necessary to evaluate each level of experience individually rather than the binary option.

- Knows about vote verification

This variable is included to determine whether or not the knowledge of a control method is sufficient to increase the levels of usage. If that is true, then the assumption would be that higher knowledge about control mechanisms and transparency add to usage. Even in

the case of those methods not being utilized in reality, or are utilized by an insignificant amount of individuals. It is also selected because in this research paper it is intended to evaluate whether the knowledge about these methods would add users, and how significant those trends would turn out to be.

The question asked from the respondents was: “Do you know that in the 2013 local elections it was possible to verify that the online vote was counted as cast?” and the possible pre-determined options for answers were the following: “Yes”, “No”, “Refusal” and “Don’t know”. Since this variable is already in a state where it gives clear binary results, it was not necessary to transform it further.

- Trust towards internet voting

Since trust is brought out by several documents as one of the main characteristics which would increase citizen participation in the digital society and usage of e-services, it is important to find out what and how trust influences the levels of usage. In order to do so it is vital to see how different behavioral patterns or daily actions affect trust. In addition, trust towards services that need to have higher levels of security could be harder to gain. Therefore, to examine trust, in the context of this research paper, the trust towards internet based voting solution is being assessed. It is also used, because it doesn’t only represent one service provider rather than a state as a whole and if individuals are able to increase trust in the state and it’s services overall, the intended goal of gaining more people included to the digital world would be perhaps more reachable.

The statement to which the respondents were asked to answer was: “Please say on a scale of 0 to 10, how much do you personally trust the following transactions on the internet. 0 means you do not trust it at all and 10 means you trust it fully”, the service was categorized as: “Online voting” and the possible answers were in addition to 1 to 10 also “Refusal” and “Don’t know”. Since trust is visualized as one notable influencer, the impact is evaluated as the whole scale and not being transformed into binary values.

- Usage of internet voting

As a dependent variable, it is determined, how other variable would affect usage rates of public sector e-services. In order to determine that, the mode of a person casting their vote is evaluated. The question to which the individuals needed to respond was the

following: “How did you vote in the 2017 local elections?” and “How did you vote in the 2015 national elections?” with the possible pre-determined answers as the following: “Voted on the election day”, “Voted in advance polls at polling station”, “Voted in advance polls by internet”, “Other”, “Refusal”, and “Don’t know”. In this case, the results are transformed into binary values, so that it is possible to determine the individuals that voted over the internet to the ones that didn’t, as presented in the following table (Table 5):

Table 5. Binary coding of the Usage of internet voting variable.

Original value	UsedInternetVotingDummy
1 Voted on the election day	0
2 Voted in advance polls at polling station	0
3 Voted in advanced polls by internet	1

This enables to differentiate the individuals that used internet based voting compared to the ones that didn’t, regardless of which option of not using internet voting they preferred.

- Age

In addition to the variables listed above, another variable is being used in order to check the model and the end results. However, in the case of this variable, it is intended only to be carried along in order to eliminate that it would have significant impact on levels of usage. It is also important, that however interpreted, age is considered to be a proxy variable in the context of this research. The question to which the individuals needed to respond was the following: “What is your age?” and the possible answers were given in full numbers, starting with “16” as the minimum age on the Local Elections in 2017 was 16.

- Gender

The following variable is added as a socio-demographic variable and has the intention to determine if there is any scientifically significant difference between males and females when it comes to the usage of online voting in the context of this research paper. The possible responses to the gender were “Male” or “Female”.

- Education

Much like the two previous variables, this is also carried along to check that the impact is not actually dependent on the level of education itself, rather than it affects the results as a proxy variable. The question asked from the respondents was: “What is your level of completed education?” and the predetermined answers were: “Elementary/Basic”, “Secondary education/Gymnasium”, “Vocational secondary education” and “Higher”.

Much like digital skills, this set of ordinal values would be transformed into two separate dummy variables where it is possible to take lower levels of education as a reference, as presented in the following table (Table 6):

Table 6. Binary coding of the education variable.

Original value	EducationDummyHigher	EducationDummySecondary
1 Elementary/basic	0	0
2 Secondary/gymnasium	0	1
3 Secondary/vocational	0	1
4 Higher	1	0

These changes done to the variables enable to carry out an analysis where the data has been modified to give results that can be specifically interpreted. In order to evaluate the impact of certain aspects to usage of services and impact of trust, a set of hypotheses will be created. In the following paragraph, these hypotheses will be introduced more specifically.

2.2. Hypotheses

Based on the ten variables, six hypotheses are being constructed in order to determine if and how non-socio-demographic characteristics could affect levels of usage of public sector e-services amongst individuals. The hypotheses are designed to evaluate the correlation between vital digital skills and access to multiple factors that might affect usage. The hypotheses are the following:

H1: Higher digital skills provides higher usage of internet based voting.

The assumption in the case of H1 is that if usage can be affected by their digital skills. If that is correct, then it is clear which capabilities should be increased in order to make sure that the long term goals of digital inclusion and usage are fulfilled. In order to evaluate that hypotheses the author uses one independent variable – digital skills, which is represented and coded as the variable “PC literacy” in this dataset.

The dependent variable in this hypothesis is “Usage of internet voting” in order to evaluate if the individual actually voted over the internet or not. The intention of using that variable is to evaluate to what extent higher digital skills affect the actual usage of an e-service, which in the case of this research is internet based voting.

The assumption is that if H1 is true, then people’s digital skills would manifest as a higher usage of internet voting and/or other e-services provided by the public sector.

H2: Better access to a smart devices provide a higher usage of internet based voting.

Similar to H1, H2 focusses on usage of internet based voting as a dependent variable and access to a smart device as an independent variable. Assuming that if people have indeed better access to use such devices, then they can and will also use them in order to utilize the service consumption options which are provided by the government. An important aspect here is that currently it is not possible to vote using a smart device, however it is possible to verify a vote using a smart device and therefore it is used in this model. It could also be assumed that if people are more familiar with such devices, they would also be familiar with other devices, such as computers, as there would have been already more time to get used to those. Of course there cannot be made a direct link between usage of computers and usage of smart devices, as was also pointed out in the first paragraph of this research paper, however, it can be used to estimate the links between access to a device and usage of services. The aim of this hypothesis is to evaluate how important it actually is to have access to newer, cheaper and perhaps more user friendly technologies to be able to use e-services. As the dependent variable, much like in H1, in H2 usage of internet based voting is being used.

H3: Higher levels of internet usage provide higher usage of internet based voting

In the third hypothesis, the variable that will be under examination is the usage of internet and as the intention is to determine if individuals that are more active users of the internet would be more likely to vote over the internet compared to the individuals that don’t use

the internet actively. In order to do so the independent variable is usage of internet and the dependent variable that will be examined is the usage of internet voting by the individual. The assumption in this case would be that the individual that is using internet more actively will be more likely to vote over the internet.

H4: Usage of QR codes provide a higher usage of internet based voting.

In the case of H4, the interest moves from access to the internet towards more complex methods, which might suggest that the capability to utilize them in a person's benefit will also have some effect on how the person feels in the surrounding environment. Therefore if a person has higher user experience rates and has had previous ability to use a QR code previously, then they might have higher usage rates towards a service, which enables to control their decisions by utilizing these capabilities. Therefore the independent variable visualized in this hypothesis will be previous usage of QR codes and the dependent variable will be usage of internet based voting. In this hypothesis the assumption would be that more experience with QR codes would increase usage of a service, which enables to utilize the usage of QR codes to increase transparency. If that is accurate, then it would be easier to determine which skills and competences would have to be increased in individuals to start utilizing the benefits of using services that demand an elevated level of security. It is also possible that even if an individual lacks the possibility to utilize the opportunity of using a complex method to evaluate the e-service used or action taken, they would still trust the procedure more, if there is confirmation about a method that would give that individual (and others) to do it.

H5: Higher trust towards internet based voting provides higher rates of using internet based voting.

The fifth hypothesis (H5) is intended to test whether actually increasing trust towards a service will increase the usage of that service. This is vital to determine in order to evaluate if raising the trust levels would even have the assumed effect on usage, or if perhaps more aspects should be included in the process of getting EU citizens using e-services. In the fifth hypothesis the independent variable is trust and the dependent variable will be usage of internet based voting. It is evaluated how trust towards internet based voting actually affects the individuals decision to cast the vote over the internet and

if the links turn out to be positive, it can perhaps be established how to increase usage, by increasing trust.

H6: Better knowledge about vote verification options provides higher usage of internet based voting.

The final hypothesis (H6) is intended to evaluate whether knowledge about a specific method which might provide added transparency to an e-service actually does manifest in higher rates of usage amongst the individuals that have that knowledge. On the contrary it could turn out that even if people have better knowledge about control mechanisms, it is not sufficient to increase the levels of usage of that service. In order to test it with this hypothesis, two variables are being used. The first, independent, variable will be knowledge about the possibility of vote verification options and the second, dependent, variable will be usage of internet based voting.

In addition to the hypotheses, to carry out this research three additional independent variables are being added in order to determine that socio-demographic characteristics of individuals would not matter and the results would become insignificant in terms of this research. The added variables would be age, education and gender. There would be a possibility to also another variable like wage, but it tends to represent similar characteristics as education. In order to carry out this research, however, three of those characteristics will be added (age, education and gender), not to measure the impact of them, rather than to eliminate the chance of not being able to interpret the results disregarding proxy variables that are not necessarily linked to usage themselves, rather than are disguises of other changeable factors (independent variables used in this research).

In addition to the previously constructed hypotheses, it is also vital to take a closer look towards the methodology and data that is being used in this research. The following paragraph focuses on the origin of data and the characteristics of the data. After that, a closer look is taken on the specific method of statistical analysis that is being used in this research.

2.3. Methodology and sample description

The data for this research originates from post-election surveys carried out by K.Vassil and M. Solvak after general elections in Estonia from 2013 to 2017. In order to proceed

with this current analysis, data is taken from the past two elections and treated separately. The reason for that comes from the specifications of each of those elections where in the 2015 Parliament Elections only citizens could participate and the 2017 Local Elections all permanent residents could cast their vote. In total each survey concluded 1000 participants, who were selected using stratified random sampling according to the age, gender, place of residence and education. In addition, the answers of the participants that refused to answer to certain specific questions or could not answer those questions, is being disregarded. In order to carry out the research an array of statistical analysis methods are being used, starting from simple statistical evaluation and moving towards more complex methods, such as logistic regression analysis. In order to carry out the statistical analysis IBM SPSS is being used. In certain aspects, also Microsoft Excel is being used, especially to consolidate and visualize the outcomes of the research. In the following paragraph, a closer look is taken upon logistic regression analysis and the assumptions that need to be fulfilled in order to carry out this type of statistical analysis.

Before introducing the specific models and the analysis is being carried out, the specific characteristics of each variable are being represented according to the responses that the individuals have given. It consists of the percentages that each response was given as well as the minimum, maximum and mean age of the respondents in 2015 and 2017. These results are presented in the following table (Table 7.):

Table 7. Characteristics of responses, 2015.

Variables	Answer distribution											
PC Literacy	No Computer Skills		Basic		Average		Good		Very Good			
	15.4%		11.9%		30.8%		27.4%		14.2%			
Access to a smart device	Yes, Smartphone		Yes, Tablet		Both		No					
	28.8%		6%		17.1%		47.7%					
Internet usage (days per week)	0	1	2	3	4	5	6	7				
	21.7%	3.1%	4.4%	5.6%	4.0%	7.3%	4.5%	46.6%				
QR code usage	Yes, many times		Yes, sometimes		Never		Don't know QR codes					
	4.1%		9.4%		29.8%		56.7%					
Knows about vote verification	Yes	No										
	41.2%	58.8%										
Trust online voting	0	1	2	3	4	5	6	7	8	9	10	
	14.6%	3.9%	2.9%	3.9%	3.6%	7.4%	11.1%	9.7%	11.6%	15.2%	16%	
Usage of internet voting	Yes	No										
	24%	75%										
Age of Respondent	Min.	Max.	Mean									
	18	92	50.18									
Gender	Male	Female										
	44.6%	55.4%										
Education	Elementary/ Basic				Secondary				Higher			
	18.1%				52.2%				29.7%			

These results are presented in order to have clear understanding in terms of the responses that the participants gave and they will be taken into account during the following stages of the analysis carried out in this research paper. In addition to the results in 2015, in the following table (Table 8), the results of 2017 are presented:

Table 8. Characteristics of the responses, 2017.

Variables	Answer distribution											
PC Literacy	No Computer Skills		Basic		Average		Good		Very Good			
	7.5%		8.8%		30.8%		28.8%		24.1%			
Access to a smart device	Yes, Smartphone		Yes, Tablet		Both		No					
	28.2%		3.8%		43.9%		24%					
Internet usage (days per week)	0	1	2	3	4	5	6	7				
	9.5%	1.5%	2.3%	2.8%	2.0%	2.3%	1.1%	78.6%				
QR code usage	Yes, many times		Yes, sometimes		Never		Don't know QR codes					
	12.0%		17.6%		38.5%		31.9%					
Knows about vote verification	Yes	No										
	42.8%	57.2%										
Trust online voting	0	1	2	3	4	5	6	7	8	9	10	
	11.2%	1.9%	3.7%	3.2%	3.9%	6.6%	3.4%	6.1%	13.7%	17%	29.3%	
Usage of internet voting	Yes	No										
	38.8%	61.2%										
Age of Respondent	Min.	Max.	Mean									
	19	92	50.37									
Gender	Male	Female										
	49.1%	50.9%										
Education	Elementary/ Basic				Secondary				Higher			
	8.6%				51.5%				39.8%			

In the next paragraph the focus is to elaborate on the specific regression analysis method that is being used in this research.

2.4. Multiple Regression Analysis

In order to carry out this research descriptive statistics was used to describe the basic features. In order to carry out regression in a situation where the dependent variable has a categorical outcome it is suitable to use logistic regression analysis. First of all, regression analysis value as a research method is high because of its versatile application to various study contents. (Stoltzfus, 2001) Another benefit of such analysis is that the dependent variable can have multiple categorical outcomes. (Dayton, 1992) However in case of a dichotomous dependent variable certain limitations like homoscedasticity, linearity and normality are violated which means that the accuracy of the model could suffer. In order to overcome this inefficiency, the maximum likelihood estimation of a logistic regression transforms $Y (1, 0)$ into a logit or log of the odds of falling into the “1” category. (Menard, 2002)

The binary outcome of the predicted values of a regression model could also fall outside the 0-1 range, however in order to solve that issue, logit scale mathematically transforms the original linear regression equation to yield the natural log of the odds of being one outcome or the other outcome. (Stoltzfuss, 2001) Based on theoretical background information (Hosmer et al., 2013, 7), the logistic regression model can be visualized as the following:

$$\ln \left\{ \frac{Pr(y = 1)}{1 - Pr(y = 1)} \right\} = \beta_0 + \beta_1 x_1 + \dots + \beta_n x_n + \varepsilon$$

where:

y = dependent variable

x_i = independent variable

β = parameter

ε = error

n = number of independent variables

However in the case of logistic regression analysis, violating these assumptions are more forgiving to certain extent if certain assumptions remain unviolated. These assumptions are independence of errors, linearity in the logit for continuous variables, absence of multi collinearity and lack of strongly influential outliers. (Stoltzfus, 2011, p1099)

In a later stage, after the analysis, the assumptions will also be checked and if there should be any discrepancies then the results will be interpreted accordingly. In the following paragraph the results of the analysis are being evaluated and other empirical steps are taken in order to fulfil the aim of this research.

Since this research is intended to evaluate not only the impact of specific variables to the overall usage of public sector e-services, rather than to see how trust as a predominant variable impacts the usage of these services, there are two separate models that will be carried out.

The first model is the following:

$$\ln \left\{ \frac{Pr(y = 1)}{1 - Pr(y = 1)} \right\} = \beta_0 + \beta_1 x_1 + \dots + \beta_n x_n + \varepsilon$$

where:

y = Usage of online voting

x_1 = Age of respondent

x_2 = Highest graduated education

x_3 = Gender

x_4 = Trust online voting

In addition to the first model, this research paper also has a second model in order to determine and analyze if trust itself individually has a predominant role or skills affect the importance of trust and become more relevant as the importance of trust, in that case, would decrease. However, in this model, there are various aspects included that might also be of relevance in terms of interpreting the outcomes of actual usage levels. In this case digital skills are added as well as knowledge of methods of verification in using a specific service. The second model is the following:

$$\ln \left\{ \frac{Pr(y = 1)}{1 - Pr(y = 1)} \right\} = \beta_0 + \beta_1 x_1 + \dots + \beta_n x_n + \varepsilon$$

where:

y = Usage of online voting

- x_1 = PC literacy
- x_2 = Access to smartphone or tablet
- x_3 = Internet usage (days per week)
- x_4 = Has used QR code
- x_5 = Verification (knows about it)
- x_6 = Age of respondent
- x_7 = Highest graduated education
- x_8 = Gender
- x_9 = Trust online voting

These two models enable to evaluate the impact specific variables might or might not have as well as determine if trust actually is the main influencer or perhaps digital skills play a far greater role in engaging individuals into usage of public sector e-services. These results could then be used in order to evaluate and establish how other institutions as well as states could give incentives to individuals in order to utilize the benefits of public sector e-services.

2.5. Results of analysis

In the following paragraph, a closer look is taken towards the results of logistic regression analysis in terms of the hypotheses during two separate elections, respectively in 2015 and 2017. The analysis is run in IBM SPSS and results are visualized in the form of a table. The first table (Table 9.) consists of the results taken from the first model and is as the following:

Table 9. Results of Model 1 logistic regression analysis.

	2015		2017	
	Sig.	Exp(B)	Sig.	Exp(B)
Education: Higher (base: Basic)	.008	2.433	.000	5.637
Education: Secondary (base: Basic)	.211	1.507	.021	2.807
Age of respondent	.299	.994	.691	1.002
Gender of respondent	.004	1.748	.011	1.538
Trust online voting	.000	1.532	.000	1.537
Constant	.000	.019	.000	.005
Nagelkerke pseudo R Square	.318		.346	
	% correct		% correct	
True negative	88.8		78.9	
True positive	36.6		59.2	
Overall %	74.3		72.2	

The aim of the first model is to determine how socio-demographic characteristics affect the overall likelihood of a person voting over the internet where trust is added, but no other digital skills or related variables are in the model. It is seen, that trust itself has had very similar impact to the fact of voting over the internet or not over the two elections observed. In both of the cases the significance of the variable is statistically important and the Exp(B) in these cases can be interpreted as that in 2015 as well as in 2017 the likelihood of an individual voting over the internet was in both cases 53% higher than the likelihood of a person that did not trust internet voting. It is also clear that in this case the education plays an important role. In 2015 the importance of individuals that had higher education compared to the ones that had only elementary or basic education is higher 2.433 times or as interpreted to percentages 143%. However, the same indicator in 2017 has similar, or a bit higher significance and also the effect is 5.637 or 463% higher compared to the individuals that had elementary or basic levels of education. In this case it can be determined that higher levels of education truly has impact to the end decision of voting over the internet or not. In addition, as education is also observed in the case of having secondary education compared to elementary or basic levels of education, the differences are not as substantial as it is in the case of higher education. In 2015 the

statistical significance is not there and in 2017 it is, however lower than in the case of higher education. Still the impact is relevant and it suggests that individuals that had achieved secondary level of education were more likely to vote over the internet 2.807 times or 180%. This means that overall, in a situation where digital skills themselves are not being observed, the impact of education is relevant as well as strong. This is noticed, however before definitive conclusions can be made, a closer look has to be taken on the second model as well, in order to determine how other skills in relation to education would affect the overall levels of using internet voting or not using internet voting.

As there are two other socio-demographic variables in this model, it is seen that over the two elections observed, the age of the respondent did not play a statistically significant role and therefore it can be assumed that the age of the individual is not a relevant characteristic that would impact the decisions in the context of this research paper. However, the gender of the respondent is in both elections scientifically significant and it is seen that if the respondent is male, then the likelihood of voting over the internet compared to the situation where the respondent was female is in 2015 1.748 or 74% higher and in 2017 the same results are 1.537 or 53%. That is taken into consideration, but as with the previous variables, in order to have conclusive results, it is important to evaluate also the levels of significance and impact in the second model.

The last variable in this model is trust and over the both observed elections it has had very high scientific significance and also the impact is strong and positive. In 2015 the level of impact according to this model is on average 1.532 times or 53% in every added level of trust. As the scale of this variable is from 1 to 10 then on each individual that has one added level of trust towards voting over the internet the likelihood of them voting over the internet is on average 53% higher. Therefore it can be stated that the individual that has the highest measured level of trust towards internet based voting compared to the individual that had the lowest measured level of trust towards internet based voting is 530%. In such case, the impact of trust is considerably high. Therefore it can be verified that in the context of this research paper, trust is indeed a predominant variable which affects the actual decision of voting over the internet greatly.

However, before further conclusions can be made, it is necessary to also take into consideration the results of the second model. That gives the opportunity to evaluate the overall significance and impact of these variables.

In terms of the model being representative and statistically significant Nagelkerke pseudo R Square is also taken into examination. Over the both observed elections it is seen that this model has relatively strong power in explaining the effects of individuals voting over the internet and in 2015 as well as in 2017 the levels were similar, .318 and .346. Therefore it can be said that this model has around one third of the explanatory power in order to predict the outcome of the independent variable. Additionally it is important to see how the model has been able to evaluate the results in a real life situation and it turns out that the overall percentage levels of being accurate are over these two observed elections 74% and 72%. Keeping that in mind, also the levels of being able to assess accurately the individuals that actually ended up voting over the internet and the ones that actually ended up not voting over the internet, it can be seen that it is more accurate in the case of individuals who did not vote over the internet.

In terms of statistical significance it is visible that in case of the first model, trust is the predominant variable and also the variable which compares individuals that have higher level of education to the ones that have elementary or basic level of education is also significant. The gender of the respondent has over the two observed elections similar impact and the age of the respondent together with the variable that considers secondary level of education compared to elementary or basic level also does not have remarkable significant impact to the model.

The results of the logistic regression analysis of the second model are represented in the following table (Table 10):

Table 10. Results of Model 2 logistic regression analysis.

	2015		2017	
	Sig.	Exp(B)	Sig.	Exp(B)
PCliteracy: Good Skills (base: poor & no skills)	.268	1.764	.062	3.061
PCliteracy: Average Skills (base: poor & no skills)	.728	1.181	.149	2.317
Access to smartphone or tablet	.067	1.612	.400	1.306
Internet usage	.004	3.848	.481	.635
Has used QR	.072	1.669	.062	1.455
Verification (knows about it)	.000	2.702	.000	2.469
Education: Higher (base: Basic)	.435	1.342	.046	2.653
Education: Secondary (base: Basic)	.864	1.063	.270	1.691
Age of respondent	.070	1.016	.020	1.018
Gender of respondent	.134	1.385	.155	1.293
Trust online voting (2013-2017)	.000	1.477	.000	1.445
Constant	.000	.003	.000	.003
Nagelkerke pseudo R Square	.421		.391	
	% correct		% correct	
True negative	87.9		82.7	
True positive	58.2		61.9	
Overall %	79.4		75.5	

The aim of the second model is to determine how the socio-demographic characteristics and trust impact changes, if at all, as more variables are being included to the model. It helps to determine the necessary influence of trust and whether the added variables would significantly change the impact of trust compared to the previous model. First of all, it is seen that in the case of added variables, the variables from the first model become less significant. That of course is a foreseeable outcome, however the exact changes could entitle unexpected results. The first variable that was added to this model does not seem to have statistically significant impact in the context of this research paper. It turns out that the individuals that have good computer literacy skills as well as the ones that have average computer literacy skills are not statistically significantly more likely to e-vote, compared to the ones that have no or basic computer skills as the Sig. levels in 2015 and

2017 are .268 and .062 in case of good computer skills and .728 and .149 in case of average computer skills, which all are outside of the predetermined levels of significance. It is however noticeable that in 2017 the levels of good computer skills are just outside the level of .05, but even so, cannot be observed in a statistically significant manner. One other aspect that needs to be referred to is that in both of these variables, they were closer in 2017 to have statistical significance than in 2015.

The third independent variable that was included in this model is the access that respondents had to a smart device, such as a smart phone or tablet and similar to the previous variables, it also does not have scientifically important significance in the context of this research paper as the Sig. levels are in the two observed elections at .067 and .400.

The fourth independent variable is the usage of internet and it is visible that individuals in the case of respondents in 2015 it has statistically important significance but in 2017, as the voters were based on different characteristics, the significance was not there. It appears that in 2015 elections, the respondents that were more active in using the internet were 3.848 times more likely to vote over the internet compared to the ones that were less active or did not use the internet at all. It can also be defined as those individuals that were more active in using the internet had the 284% higher likelihood to vote over the internet compared to the others.

In addition the previous usage of QR codes was added to determine if individuals would have the necessary skills to verify their vote if there was a will to do so. It appears that this did not have statistical significance in either of the two elections as the Sig. levels were just outside the predetermined parameters at .072 and .062. Another variable that was included to this model is the knowledge of verification methods that in real life situation would help to perhaps limit the fear of not getting the result hoped from an action and therefore the knowledge of ability to verify it indicates to have strong statistical significance in the context of this research paper. It appears that over the two observed elections in 2015 and 2017 the respondents that knew about the option of verifying their vote were 2.702 and 2.469 times more likely to end up voting over the internet. In other terms it means that the individuals that knew about that option compared to the ones that did not know about that option voted 170% and 149% more likely over the internet.

Therefore it can be stated that it indeed is important to at least know about the options of verification, even if it does not necessarily mean that that option was used. The variables that evaluated the impact of education, or more precisely the higher level of education compared to basic or elementary level of education and secondary level of education compared to the reference of basic or elementary level of education did not show to have statistical significance in this model with the only exemption of 2017 where the significance level of higher education was at .046. In that case the individuals that had higher education compared to the ones that had elementary or basic level of education were 2.653 times or 165% more likely to vote over the internet. In the rest of the cases the relevance of this variable comes out when it is compared to the first model where all of the education variables were relevant with the exemption of individuals that had secondary level of education in 2015. This shows that as new variables are added, the importance of education itself could decrease. This perhaps could suggest, that education itself isn't really relevant rather than the skills that people have and that individuals that have higher level of education also tend to have better skills.

Another socio-demographic variable that was added to this model is age and it appears that age is statistically significant over both of the observed elections in 2015 and 2017 with the Sig. levels at .070 and .020. However it also appears that although the significance is high then the impact in reality is not great. That being said, the characteristic of this variable determines that on average every added year to the respondents age made it 1.016 times more likely to vote over the internet in 2015 and 1.018 times more likely in 2017. In other words, one added year meant that the individual was 1,6% and 1,8% more likely to vote over the internet compared to not voting over the internet. This of course is over the whole scale of 16 (as 16 was the age limit to participate in the elections as a voter) to 100 and the impact in specific age ranges would be different. However if interpreted as on average, then it could be stated that higher age does not keep individuals away from voting over the internet rather than it makes it more likely. That of course can only be stated with certain reservations as the actual levels in every added year of age is not evaluated with this model.

In comparison to the first model, the gender of the respondent is not statistically significant any more as the Sig. levels in 2015 and 2017 are respectively at .134 and .155. As the final variable is trust, it is clear that it indeed plays a great role in this model as

well, much like the first model. The significance levels are well inside the statistically important limits and the impact in the respondents of the two observed elections in 2015 and 2017 were 1.477 and 1.445. First of all, these levels are quite similar. They would both suggest that on average, every added level of trust towards internet voting in the respondents means that they are 47% and 44% more likely to vote over the internet. In the overall scale of no trust towards total trust it would mean that the latter is 470% and 440% more likely to use internet voting compared to not using internet voting. These levels are indeed significant and have the potential of having huge impact, but when compared to the levels of the first model it is evident that they have decreased. One reason of this could be that trust does affect the decision, but as skills are added it appears that the relevance of trust decreases. At the same time it could be interpreted as although skills are important and add to the overall outcome of the model, then trust itself is still strong and the skills do not overrule the impact of trust. If compared to the results of the first model in 2015 and 2017 the likelihood of voting over the internet as trust levels increased on average was in the case of the first model 1.532 and 1.537 and in the case of the second model 1.477 and 1.445. Taking into consideration the various aspects, it seems that trust is important and although skills add to the overall prediction power of the model, then they do not have strong impact over the independent variable of trust. Therefore it is clear that trust indeed is a significant aspect in both of the cases.

To evaluate the overall prediction power of the model the Nagelkerke pseudo R Square is being used and it appears that compared to the first model it has increased. In year 2015 it was .421 and in year 2017 .391. This suggests that the second model actually would have a higher prediction power and that the model is capable of predicting the dependent variable at a rate of 42% in 2015 and 39% in 2017. Both of which are higher than the 31% in 2015 and 34% in 2017 of the first model. It is also relevant to compare the accurate prediction power of the model and in 2015 the true negative level was at 87% and the true positive level at 58%. That is of course as predicted as the models tend to predict the outcome that is more popular with a more accurate rate however as a look is taken upon the results of the elections in 2017 then the levels have balanced and the true negative is at 82% and true positive 61%. The overall percentage of accurate predictions is in 2015 at 79% and 2017 at 75% which are both similar. In comparison to the first model the

second model is more accurate in those terms and also the trends are similar in a way that 2015 the accuracy is higher than in 2017.

According to the levels of significance of variables, it can be stated that in both of the models the most significant independent variable across the two observed elections in 2015 and 2017 is trust. In the second model however, the knowledge of having a method to verify the desired outcome of the action, regardless if it was used or not, also carries high significance. More importantly, the second model reveals that gender as well as education seems to lose relevance if more variables, which predominantly reflect skills and access are added. It also suggests that in a situation where individuals cannot be compared by the knowledge of having the ability to verify the outcome of the action, gender becomes a more important factor, however at the same time, as there is a possibility to verify the outcome with a method and individuals are aware of it, gender does not seem to have any relevance.

In the next paragraph the outcome of the results are being reviewed in the context of the hypotheses and further analysis is carried out.

2.5.1. Results of Hypotheses

According to the results of the previously carried out logistic regression analysis a closer look is taken upon the hypotheses. It is important to determine if the previous assumptions did surface in the analysis and if they did, then how it affects the usage of online voting. The outcome of the hypotheses derives from the logistic regression results, explained in the previous paragraph. The analysis includes six hypotheses, which were designed in order to validate the assumptions based on theoretical background. Afterwards these results are evaluated with the limitations that might occur in certain circumstances and then the conclusion of the analysis is being carried out. The hypotheses are evaluated as results of the both observed elections are considered.

The hypotheses and the results of the analysis are in the following table (Table 11):

Table 11. Validity of the Hypotheses.

Hypotheses	Model 1		Model 2	
	2015	2017	2015	2017
<i>H1: Higher digital skills provides higher usage of internet based voting.</i>	-	-	F	F
<i>H2: Better access to a smart devices provide a higher usage of internet based voting.</i>	-	-	F	F
<i>H3: Higher levels of internet usage provide higher usage of internet based voting</i>	-	-	T	F
<i>H4: Usage of QR codes provide a higher usage of internet based voting.</i>	-	-	F	F
<i>H5: Higher trust towards internet based voting provides higher rates of using internet based voting.</i>	T	T	T	T
<i>H6: Better knowledge about vote verification options provides higher usage of internet based voting.</i>	-	-	T	T

According to the outcomes of the logistic regression analysis the first hypotheses (H1) can be consider not to be true and therefore higher digital skills do not necessarily mean that the individual is more likely to use internet voting. That doesn't mean that digital skills are not important, rather than their impact as such is not as clear as it would be previously assumed. The importance here is that they are not perceived to have statistically important significance levels in the used models, but their impact could be hidden in the fact that trust itself is perceived as to have dominant impact above skills. If trust would be eliminated from the equation the results as such could differ. The second hypothesis (H2), much like the first one also does not find confirmation in the context of this research paper and therefore better access to a smart device does not mean that the individual is more likely to use online voting. That perhaps, to certain extent, could be explained by the fact that it is not currently possible to vote over a smart device (such as

a smart phone or tablet), but it is necessary to download the voting application to a computer (either desktop computer or a laptop).

The third hypothesis (H3) finds some confirmation in the case of the observed 2015 elections, however, in the other observed case in 2017, the hypothesis fails. Since the hypothesis does find confirmation in the first one, it could be caused by the fact that in 2015 the relevance of using internet was higher and as years passed (although only two), more individuals adopted the usage of internet and therefore there was no relevant significance between the individuals that were more active users of the internet compared to the ones that were less active or did not use internet at all. That of course still means that the ones that did not use internet at all did also not use internet voting, but the ones that used less actively compared to the ones that were more active did not show a difference in the context of this logistic regression analysis.

The fourth hypothesis (H4) did similarly to the first (H1) and the second (H2) also not find confirmation and therefore it cannot be suggested that previous usage of QR codes means that individuals are more likely to use online voting. The usage of QR codes could have impact on the levels of individuals that used vote verification during the elections, however, that is not being examined in this research paper.

The fifth hypothesis (H5) does find full confirmation in both of observed elections in both models. It is also the only hypothesis that was evaluated in both of the models. This suggests that trust indeed is a predominant aspect when it comes to estimating the likelihood of an individual using online voting. Trust itself can be observed to have significant statistical impact in all of the cases and that impact is independent from all of the other variables. Although it was lower when more variables were added in the second model, however, they did not decrease the importance of trust at a large scale. Therefore it can be stated that the fifth hypothesis (H5) does find confirmation in the context of this research paper.

The sixth hypothesis (H6) also finds confirmation and therefore it can be stated that indeed better knowledge of vote verification methods (regardless of using them or not) is relevant when estimating the outcome of an individual using internet voting or not. It could perhaps also be stated that individuals that are aware of the ability to use vote verification have higher trust towards the system and use it because of that. Alternatively

it might mean that trust as such is not considerable here, but the fact that individuals are aware that they could verify the outcome of their decision gives them enough assurance that they are willing to do it (use online voting)

As a conclusion to the hypotheses, it can be stated that trust as such has important and statistically significant impact to the outcome of voting as well as the knowledge of vote verification options are important. The levels of internet usage could have had stronger impact previously, but according to the results of the latest elections in 2017 did not find confirmation and in order to further analyze the hypotheses that did not find explicit confirmation at all, other steps should be taken. However in the context of this research paper they remain not confirmed.

2.6.Implications

In this paragraph further results and their impact will be evaluated as well as some of the factors that set certain limits to the research itself. In this case it should be considered how further steps could be taken to eliminate the unclear results of this research paper and whether some added factors would impact the results in a scientifically as well as statistically significant manner.

2.6.1. Limitations of the research

The objective of this research paper is to estimate the impact various variables might have to the usage of public sector e-services across Europe. However the specific data used in this analysis is acquired from questionnaires carried out after two elections in Estonia. Using that data, it is estimated which predetermined variables could have impact to the likelihood of an individual using online voting. Online voting itself is a rather specific public sector e-service that might need certain approach in order to make the results as universal as possible in the context of this research paper. First of all, although online voting in its essence is a public sector e-service, it carries some characteristics other e-services might not withhold. One of the limitations related to this research could be linked to the fact that online voting has certain political undertone and that the users of this e-service are more likely to be supporting one or another political group, but the supporters of other political groups are not likely to use it and therefore the results might end up being evaluated as biased or one-sided. In order to eliminate that, it could be relevant to estimate the political preferences of the respondents of the surveys that were carried out.

In the case of this research and the limitations that the data presented, it was not possible to do so. Party preferences could possibly affect trust levels as well as the likelihood of an individual voting over the internet, but in the context of this research paper it would then become relevant amongst the respondents that voted over the internet, however, the aim of this research paper was to analyze the whole set of respondents, not to focus on the ones that actually used online voting. Furthermore in case of the 2017 Local elections individuals could cast their vote according to the party preference as well as individual candidates that were representing various election coalitions (*Valimisliidud*). According to the data from the Estonian National Electoral Committee (Estonian National Electoral Committee, 2017) in 2017 26.8% of the votes went to these election coalitions, where it is not possible to pinpoint exact party preferences of an individual respondent. Altogether out of 185 871 votes 54 065 votes went to these election coalitions and/or independent candidates. (*Ibid*) This includes around one third of all of the votes that were cast online. Therefore in the context of this research paper it is acknowledged that political party preference is an important characteristic that should be incorporated in detail in the occasion of the analysis being carried out in a manner where it exclusively contains individuals that used online voting, however in the context of this research paper, where also non-users were incorporated, it was not included and the results are interpreted accordingly.

The second limitation that could affect the universal interpretation of the results is the fact that empirical data was used from one member state. Doing that, it is certainly needed to evaluate the specific economic, demographic, geographic, religious, political as well as structural peculiarities of the state, however, in a situation where Estonia, as the subject of this research paper, is considered to have certain moral high ground in the context of providing e-services compared to other European Member States, it is justified to take this information and interpret it as universally as possible.

The third limitation, which this research paper has, is the fact that data was used from two most recent elections and the previous ones were disregarded. That conscious decision was made in the context of rapid changes in the field and the fact that older data might not prove to have significant relevance in the context of the current situation. Elections occur on a basis where even using results of one of the latest previous elections (2013)

would be already outdated and in order to have as accurate results as possible, only the two latest elections (2015 and 2017) were included.

2.6.2. Conclusions of empirical study

The results of the empirical analysis suggest that trust indeed is a predominant variable that considerably affects the levels of usage of public sector e-services. In this occasion trust has been a relevant variable in all occasions it was used to evaluate the usage of services. Its importance also comes out in the case of verifying the validity of the set hypotheses. As the aim of this research paper was to evaluate how non socio-demographic variables affect the usage of e-services provided by the government, it became evident that although they have certain impact, they do not overrule the stronger impact of trust. Also as socio-demographic variables were used in the research to eliminate their importance, the results suggested that indeed their importance is low. In certain occasions age, gender and level of education did show some statistically important significance, then in reality that impact was low and did not show successive trends. Perhaps somewhat surprisingly the only variable that showed significant impact on usage levels of e-services was the knowledge of vote verification, which could suggest that complex verification methods might carry some relief to the unwillingness to use e-services. That being said, trust as well as vote verification methods can be considered, according to the results of this research paper, to have most significant impact in relation to all other variables used. In addition to these two, it can be stated that higher levels of internet usage did show somewhat assumed relation to the levels of usage of e-services, however these relations were not consistent.

When a closer look is taken on the models themselves, it can be stated, that although the results were not as originally assumed, the models had relatively high predictive power to estimate the outcome of the dependent variable. That is a good indication to carry out further analysis related to this topic and also gives proof, that these variables can be used to estimate the usage levels of e-services provided by the public sector. Also it is important to point out that although the added variables in the second model did not prove to be statistically significant, their impact was measurable and they did affect the importance of trust slightly. In addition they added to the models predictive power. In addition to that, the ability to accurately estimate the true negative and true positive results

of the model proves, that considering non socio-demographic skills as relevant enablers of increasing usage of e-services is correct. In overall estimation of the fit of these variables as well as the models, it can be stated, that they are relevant and in order to do long term conclusions, it is important to analyze them more in depth.

3. DISCUSSION

The results of this paper were to certain extent presumed, but at the same time, several of the assumed relations did not prove to have any statistical significance. That being said, the results show that trust has been a predominant variable, which has higher impact on usage of e-services than others. In the context of this research paper, it needs to be pointed out that although the analysis was carried out in relatively narrow field of study, the generalizations can be somewhat universal. It is important to point out, that although skills and trust are related to certain extent of influencing individuals to use online voting, then in the case of low skills but high trust it is still likely that those individuals would choose the option of online voting. However in the case, where there is no trust, then skills themselves would probably not have strong enough impact which would make them vote online. Therefore it could be stated, that trust building measures are absolutely vital to influence individuals moving towards e-services provided by the public sector, especially if online voting is not perceived as something that in its essence is politically influenced action, rather than a public sector e-service. In such case, the outcomes of this research could have wider impact. It is clear that e-services have a wide variety of applications and differ by the providers as well as the relevance. But if there is a way to determine how to engage more individuals in e-services that in essence already require to have higher levels of trust to be used, then that knowledge could also be utilized in providing valuable input on how to get individuals trust and use other types of e-services as well. It is clear that today, the biggest challenge is not to get individuals ordering goods and services over the internet, rather to carry out the needed interactions with the authorities over the internet. This is necessary not only to run a more efficient bureaucratic system, rather than to guarantee that everybody that needs to use a service, can use the service, regardless of the time, location or device that they are using. On one side, this is important for a state to be sure that all who are in need, can ask for the help they need, but on the other side related to the fact that in order to guarantee the principles of democratic processes, individuals might need to access certain services away from the government offices. Even in the case of elections, not everybody is perhaps able to access the election offices to cast their vote, but providing them with the ability to cast the vote regardless of the limitations that individuals have, guarantees the outcome of true democratic processes.

In order to make long term conclusions, it is important to briefly address some of the limitations that are there. As it was pointed out previously, the data used in this research paper originates from a very specific field of study and it could be complicated to universally broaden the results on other fields, but keeping in mind that in the essence the importance of this research comes out in verifying the specific variables that affect overall usage of a service, the results could perhaps be interpreted as needed to a wider context.

These results could be taken and used by the Estonian government to further enhance the usage of e-services amongst the population but also by other countries that are perhaps struggling today with getting individuals engaged in every day democratic processes. As it is clear that there is a need for certain EU Member States to significantly improve not only the usage of e-services, but actually the whole concept of providing services overall, these results could be used to provide certain confirmation that trust as well as transparency are the most important aspects of any service. In addition, to certain extent it could be argued that in addition to the two previously mentioned variables, also access plays a certain role and in the world of e-services access means internet. Not just internet, but fast, reliable and affordable internet anywhere on the territory. This of course would be a bigger challenge to Member States that have a larger territory or dramatic landscapes, but it is absolutely vital to have these channels of communication available in as widely as possible.

In order further develop this research paper in the future, it could be relevant to add more data to the analysis not by adding new variables, rather than evaluating which variables uniquely have higher significance and perhaps substitute the ones that don't seem to be as relevant. In addition it could prove important to add more datasets to the analysis and then estimate the newest trends in the field. As the information and telecommunication technologies are developing at rapid speeds, it would be important to carry out similar research in the future with added data. Another option is to separately estimate the relevant variables when providing private sector e-services and then estimate how these overlap with the variables that influence public sector e-services. All in all, the results of this research give a relatively adequate understanding on what actually impacts the usage of e-services which require enhanced levels of trust, but before any long term conclusions are made, further analysis and interpretation of the results is needed.

SUMMARY

The aim of this research paper was to indicate clarify the current situation in the European Union in terms of usage of e-services provided by the public sector and the different variables which could affect that. In addition it was important to find a specific state which could be used as a role model to others and since Estonia has ranked high in various international ratings and rankings that evaluate such development. Additionally it was possible to retrieve information from two previous elections from Estonia, in 2015 and 2017, to evaluate which certain variables which might affect the overall levels of usage of online voting and through these variables also generalize the outcome to other e-services provided by the public sector. In in order to do so logistic regression analysis was used to evaluate the validity of predetermined hypotheses. These hypotheses focused on different variables that could have impact on the usage of services. The assumed predominant variable in this research paper was trust towards the service itself and as the analysis was carried out, it confirmed that trust indeed plays a significant role in the prediction power of the models, which were designed to evaluate the impact of trust, other non socio-demographic characteristics, such as access to smart device, usage of internet, knowledge of verification and usage of QR codes. Therefore it can be stated that higher trust levels towards internet based voting indeed provides higher levels of using internet based voting. Not only did trust have a consistent impact, but in because of the specific scale of the variable the overall impact between lower levels of trust compared to higher levels of trust was relevant.

Additionally to trust better knowledge about vote verification options higher usage of internet based voting. Although the results of usage of QR codes did not provide consistent statistically significant results to usage of internet based voting, it can still be stated that this could be partially confirmed, but further analysis on the reasons needs to be carried out.

In addition to these models six hypotheses were established. Out of these six predetermined hypotheses, two were accepted as true, one of them is partially confirmed, but others did not find confirmation in the context of this research paper. This could indicate that their significance does not prevail in such setup, but can considered to have

impact to the significance levels of other hypotheses. It can be stated that trust as well as knowledge of verification methods add to the predictive power of a model to estimate the probability for an individual to use a certain service, which in this case was the usage of online voting. Additionally, the active usage compared to non-active usage of the internet only showed to be true partially and did not have consistent results. Therefore it can be stated, that this is only partially confirmed. It is also clear that although usually perceived as important, socio-demographic characteristics did not play a significant role in the outcome of this research. In order to carry out the logistic regression analysis the majority of the variables were coded into binary results so that the true impact of active versus non active users could be estimated. Also this was done in certain occasions to keep some responses of the categorical variables as a reference and evaluate the impact that higher categories had in relation to categories that were perceived as lower. In the case of education the lower categories were elementary and basic level of education and the higher ones secondary level and higher level. The same was done to PC literacy levels were no skills and basic skills were kept as a reference and higher levels were compared to those.

The overall predictive power of the two models presented in this research paper were relatively high with the Nagelkerke pseudo R Square levels of .318 and .346 in the case of the first model and .421 and .391 in case of the second model. As more variables were added to the second model and they did not appear to have relevant significance levels to be used individually, they still had impact in providing more predictive power to the overall usage of internet based voting. In addition to estimate the true correct predictive percentages of these two models, the first one had an overall correct predictive percentage level of 74.3 and 72.2 respectively in 2015 and 2017 and the second one 79.4 and 75.5. This also suggests that the second model, which had more variables, had the higher correct predictive percentages.

These results give the opportunity to evaluate the variables which actually impact the levels of trust in the case of internet based voting and these results, if interpreted accurately could also give significant input to further analysis in other fields of study. That of course would be possible if other characteristics and peculiarities of these fields are taken into account. In terms of the limitations that were presented in this research it is vital to consciously accept the fact that internet based voting is a rather specific variation

of an e-service which is provided by the public sector. This means that in order to carry out further analysis it could turn out to be relevant to also take into account the political party preferences of the respondents. However in the case of this specific research, this would have impacted the focus of the research in an undesirable manner and was therefore excluded from the initial research. Perhaps the most relevant finding of this research can be concluded that although skills have some effect to the predominance of trust, then in a situation where individuals have high trust but low skills, they would still consider using e-services, but in a situation where there is no trust, that would not occur. Therefore it can be stated, that the most important aspect for states would be to strongly focus on trust building measures.

All in all it can be stated that in the context of this research paper the results are scientifically important and can be used as input to carry out further analysis. The limitations need to be kept in mind and when interpreting the results also mentioned, but overall results of this paper are relevant. Since there is no previous research that focuses on the same manner to these relations between the independent and dependent variables these results give an opportunity to evaluate and tackle the challenges provided in the first part of this paper adequately.

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AVALIKU SEKTORI E-TEENUSTE KASUTAMISE ANALÜÜS EUROOPA LIIDUS: JUHTUMIUURING EESTI KOHTA

Indrek Önnik

Resümee

Üha kiiremini muutuv maailmas on praegusel hetkel teenusepakkujate üheks suurimaks väljakutseks enda teenuste digitaliseerimine ning automatiseerimine. Selleks, et säilitada või omandada konkurentsieelist teiste teenusepakkujate ees on vajalik mitte ainult rohkem teenuseid teha digitaalselt kättesaadavaks, vaid ka leida ka reaalseid kasutajaid. Sarnaselt erasektorile on selliste väljakutsete ees ka avalik sektor. Kuna inimesed on liikumas üha enam paberilt elektrooniliste lahenduste suunas, on oluline, et avaliku sektori teenusepakkujad oleksid võimelised muutuva ajaga kaasas käima. Sarnaselt teistele teenusepakkujatele, on ka nende jaoks väljakutseks inimeste kaasamine teenuste kasutamisesse. Seda silmas pidades on ka regionaalsete rahvusvaheliste organisatsioonidele väljakutseks liikmesriikide ühtlase arengu tagamine ning mahajäämuse pidurdamine. Antud töö kontekstis on nende väljakutsete keskmises Euroopa Liit, mille osad liikmesriigid on selgelt antud valdkonnas tugevamad, kui teised ning regionaalse kompetentsivõime säilitamise seisukohast on oluline leida lahendusi sellise olukorra vältimiseks, kus liikmesriikides ei suudeta tagada elementaarsete teenuste pakkumist digitaalsel teel. Sellises olukorras ei ole saanud oluliseks mitte teenuste pakkumine, kui asi iseeneses, vaid inimeste kaasamine teenuste kasutamisesse. Praegusel hetkel on Euroopa Liidu tuleviku suunatud programmide raames seatud fookusesse just digitaalsele arengule kaasa aitamine ning inimeste kaasamine nendesse protsessidesse. (European Commission, 2018c) Sellest tulenevalt on välja toodud ka mitmed fookuses olevad aspektid, millega on plaanis tööd teha. Ühelt poolt on aru saadud, et inimeste kaasamine teenuste kasutamisesse on seotud usaldusega ning teisalt on selge, et ilma vajalike oskusteta pole võimalik eeldada, et inimesed hakkaksid teenuseid elektrooniliselt kasutama. (Ansip, 2017) Kuna, aga oskused ja usaldus on vaid üks osa vajalikest eeldustest, kontrollitakse antud töös ka teiste parameetrite olulisust, vältimaks olukorda, et need osutuvad teaduslikult oluliseks ilma neid arvestamata.

Antud töö eesmärk on hinnata ning analüüsida erinevate muutujate olulisust avaliku sektori poolt pakutud e-teenuse kasutamisel ning selleks kasutatakse logistilist

regressioonianalüüsi. Töös läbi viidud analüüsi tulemusel on võimalik hinnata erinevate muutujate olulisust ning teha ka spetsiifilisest valdkonnast väljapoole ulatuvaid otseseid ning kaudseid järeldusi, pidades silmas ka analüüsiga seonduvaid piiranguid.

Selleks, et kontrollida erinevate oskuste ja usalduse olulisust, on antud töös kasutatud kuut hüpoteesi, mis antud küsimustele vastuse peaks andma. Kuna Eestit on vaadeldud üheks Euroopa Liidus esinumbriks e-teenuste pakkumise ning kasutatavuse poolest, on antud töös kasutatud analüüsi tegemisel andmeid Eestis pakutava e-hääletamise lahenduse kohta. Kuna antud teenuse eelduseks võib lugeda kõrgendatud usalduse olulisust ning erinevate digitaalsete oskuste esinemist, võimaldab see luua ka otseseid ja kaudseid valdkonnast välja ulatavaid järeldusi. Algandmed on saadud K.Vassili ja M.Solvaku poolt läbi viidud küsitlustest, mis kogusid andmeid peale Eestis toimunud valimisi aastatel 2015 ja 2017. Nendele andmetele tuginedes on hinnatud erinevaid parameetreid, mis mõjutasid inimeste otsust kasutada e-hääletamist või mitte kasutada e-hääletamist.

Tuginedes teoreetilistele allikatele on antud töö eesmärgiks hinnata ning analüüsida erinevate mõjurite tähtsust e-hääletamisel osalemise kasuks otsustamisel. Nende parameetrite hulka kuuluvad usaldus, digitaalsed oskused, interneti ning nutiseadme kasutamine, QR koodi varasem kasutamine, hääle verifitseerimise võimalusest teadlik olek ning sotsio-demograafiliste parameetritena ka vanus, sugu ja haridustase. Eelpool mainitud näitajatele tuginedes on töös loodud kaks mudelit, milles esimeses hinnatakse usalduse olulisust e-teenuse kasutamise kasuks otsustamisel ning teises kontrollitakse, kas usaldus on individuaalselt mõjutatav olukorras, kus mudelisse on lisatud ka teised parameetrid nagu digitaalsed oskused, interneti ning nutiseadme kasutamine, QR koodi varasem kasutamine ja hääle verifitseerimise võimaluses teadlik olek. Selleks, et andmed teha mudelis kasutamiseks sobivaks on need kodeeritud binaarseks ning olukorras, kus on autori hinnangul osutunud oluliseks võrrelda kõrgema taseme olulisust madalama tasemega, on loodud ühe muutuja asemel kaks. Sellised muutujad on digitaalsed oskused ja haridustase. Läbi viidud logistilisest regressioonianalüüsist selgus, et usaldus omab märkimisväärselt suurt olulisust olukorras, kus otsustatakse kasutada mingit avaliku sektori poolt pakutud e-teenust, milleks antud juhul oli interneti teel hääletamine Eestis. Samuti omavad mingil määral olulisust sotsio-demograafilised näitajad, kuid läbivalt see ühtlast kinnitust ei leidnud. Kui vaadelda, aga teises mudelis lisatud näitajaid, siis nende

puhul osutus statistiliselt oluliseks vaid hääle verifitseerimise olemasolust teadlik olemine. Sellele tuginedes oli võimalik kinnitada täielikult kahte hüpoteesi, mis väitsid, et kõrgem usaldus e-teenuse vastu tingib ka suurema tõenäosuse, et seda teenust kasutatakse ning, et verifitseerimise võimalusest teadlik olemine suurendab tõenäosust, et seda teenust kasutatakse. Osaliselt oli võimalik kinnitada hüpoteesi, mille kohaselt kõrgem interneti kasutatavus suurendab tõenäosust kasutada e-teenuseid. Mudelite sobivuse hindamisel kasutati Nagelkerke pseudo R ruutusi ning nendele tuginedes selgus, et antud mõlema mudeli kirjeldusvõime mõlema aasta lõikes oli piisav, ulatudes suurusjärku 30% kuni 40%. Oluliseks kujunes usalduse mõju ning lisades ka teisi muutujaid oli võimalik tuvastada usalduse olulisuse minimaalne vähenemine, kuid antud töö kontekstis tuvastati, et ehkki teised muutujad võisid sellele mõju avaldada, siis reaalsuses on usalduse olulises niivõrd kõrge, et seda on võimalik vaadelda kui individuaalselt olulist muutujat.

Hinnates saadud tulemuste olulisust ka muudes valdkondades tuleb arvestada ka teatud piirangutega. Interneti teel hääletamise puhul on tegemist avaliku sektori e-teenusega, mille kasutamine on initsieeritud ka poliitilistest eelistustest ning selle olulisuse hindamine on vajalik. Kuna aga antud töös kasutatavad andmed on saadud küsitlustest, mida viidi läbi peale 2015 aasta Riigikogu valimisi ning 2017 aasta Kohaliku Omavalitsuse valimisi, on selliste hinnangute andmine piiratud. Ühelt poolt on olnud töö eesmärgiks hinnata kõikide inimeste vastuseid, seal hulgas ka nende, kes tegelikult ei hääletanud interneti teel ning teiselt poolt on valimistel võimalik valida igasuguse parteilise eelistusega kandidaatide poolt, mis ei oleks antud töö eesmärke silmas pidades andnud adekvaatset võimalust hinnata selle olulisust. Seda silmas pidades on oluline olla teadlik võimalikest piirangutest, mis see seab, kuid arvestades töö ülesehitust on sellest olenemata võimalik teha valdkonnast väljapoole ulatuvaid järeldusi.

Üheks peamiseks järelduseks kujunes see, et ehkki madala digitaalsete oskuste, teadmiste ja interneti kasutatavusega vastajate puhul on võimalik konkreetse e-teenuse tarbimine usalduse olemasolul, siis ilma usalduseta seda ei toimuks. Seega on antud töös esitatud tulemustele tuginedes võimalik väita, et inimeste e-teenuste kasutamise tõstmiseks on oluline tegeleda usaldust suurendavate meetmete parandamisega ning seeläbi on võimalik tõsta ka avaliku sektori poolt pakutavate e-teenuste kasutatavust. Selleks, et neid järeldusi

saaks rakendada ka valdkonnast väljaspool, on oluline meeles pidada piiranguid, mis antud teenusele hinnangut andes esinevad ning neid edaspidi arvesse võtta.

Kokkuvõtvalt võib väita, et antud töö tulemused on teaduslik-statistilises mõttes olulised ning nendele tuginedes on võimalik ja vajalik antud valdkonnas viia läbi edasisi, süvitsi minevaid uuringuid. Samuti loovad need andmed hea alusbaasi valdkonnaülest järelduste tegemisel ning annavad väärtusliku sisendit võimalike esilekerkivate väljakutsete lahendamisel ning piirangute tõlgendamisel.

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annan Tartu Ülikoolile tasuta loa (lihtlitsentsi) enda loodud teose

**ANALYSIS OF USAGE OF PUBLIC SECTOR E-SERVICES IN THE EU: CASE
STUDY OF ESTONIA,**

mille juhendaja on Mihkel Solvak, PhD,

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Tartus, 21.05.2018
