UNIVERSITY OF TARTU
Faculty of Social Sciences
School of Economics and Business Administration

Berk Erkan, Demet Tasar

Is There a Significant Effect of e-Residency on Estonia's GDP?

Master's Thesis

Supervisor: Mustafa Hakan Eratalay

Tartu 2021

Name and signature of supervisor…….

Allowed for defense on …….

(date)

I have written this master's thesis independently. All viewpoints of other authors, literary sources, and data from elsewhere used for writing this paper have been referenced.

(Signature of the author) .....

(Signature of the author) .....

Abstract

e-Residency has been a critical factor since it helped establish many businesses and the worldwide advertisement of Estonia. This thesis describes whether e-Residency impacts Estonia's GDP and economic growth and, based on the results, gives suggestions for countries that do not hold e-Residency program. The analysis was being done by using the Synthetic Control Method on the Estonian economy. For the study, panel data has been used from OECD and World Bank. The results recommend even though the high number of businesses established recently and taxes it brought; e-Residency should not be founded only to contribute to GDP. On the other hand, it should not be neglected e-Residency shifted the country's social structure and helped Estonia become a leading country on rapidly developing technology worldwide.

Keywords: Synthetic Control Method, Estonia, e-Residency

Table of Contents

1. Introduction 5
2. Literature Review 7
   2.1. Historical Background 7
   2.2. Summary of the Estonian Economy 8
   2.3. e-Government and Estonia 9
   2.4. e-Residency and Synthetic Control Method 11
3. Methodology and Data 15
4. Results 23
   4.1. Further Discussions 29
5. Conclusion 31
6. References 33

1. Introduction

Estonia formed a digital community for citizens around the globe as the first country to grant e-Residency which is digital integrity that anyone in the world can apply to gain access to a program. e-residents then have admittance to the EU business atmosphere and can use public e-services through their digital identity. The leading cause of e-Residents joining this community is to operate a committed EU company online with all the instruments needed to conduct business globally. (e-Estonia, 2019)

e-Residency is a growth of digital uniqueness, and the Estonian program is currently the most advanced state-sponsored consumer digital identity program globally. Since the Estonian program's launch, the number of e-Residents has steadily grown, surpassing the Estonian government's estimates threefold. Many countries and provinces are expected to follow Estonia's guidance and will thus prepare their digital borders. The Estonian e-Residency design is also likely to set the model for Europe. (Sullivan & Burger, 2017)

The e-Residency initiative's primary goal is to improve the Estonian market and provide for the internationalization of Estonian research and development and education. Besides, we can add increasing awareness of the country as a secondary objective. e-Residency's main advantage is the potential revenue to the Estonian economy brought by the viable businesses founded by e-residents and the expanded client basis for Estonian companies. (Kotka, 2015)

e-Residency is regarded as a national start-up; some gains have already appeared for some non-governmental stakeholders; still, there are criticisms towards including it did not bring the real value to its users.

On the other hand, by the end of 2020, e-Residents have built over 13,000 enterprises in Estonia. Estonia's e-Residency program has made the state €41 million, €31 million straight from tax revenue since it originated in 2014. The country now has more than 70.000 e-Residents (e-resident.gov.ee, 2020). The economic influence of e-Residency on Estonia has not been enormous, but it has still been an essential effect on GDP. The rapid growth of e-Residency raises the question of their impact on economic growth.

This Master's thesis centers on the ICT sector's tax revenues and their weight on economic improvement to determine causality within e-Residency and GDP. This research paper presents a

comparative case study between Estonia and countries without e-Residency to detect and document e-Residency's influence on GDP using analysis and synthetic control.

The research proposes the following hypothesis:

e-Residency has a definite influence on the Estonian economy.

The research paper aims to demonstrate that e-Residency has a causal effect on the country's economy and develop suggestions for countries that do not have e-Residency programs.

Even though the e-Residency program that the government supports calculated the direct economic contribution of the program, no study was found during the literature review about calculating e-Residency's effect on Estonia's economic market using the Synthetic Control Method which makes it an intriguing matter to research. At the end of the research, it is possible to suggest to countries without e-Residency, which path they should follow to obtain the maximum gain from it, that adds uniqueness to the paper.

This paper's essential technique is the synthetic control method developed by Abadie and Gardeazabal (2003). It is one of the difference-in-differences methods and is based on measuring the outcome of an intervention on groups, like cities or countries. The method is advantageous to predict what would have happened to the treatment unit if the intervention had not occurred by examining before and after the treatment. Comprehensive guidance on using synthetic control for comparative case studies given in Comparative Politics is used as instructions for the method used in this research paper (Abadie et al., 2015).

Panel data from different data sources that include various predictors for each control country were gathered to complete the study. The dataset was extracted from the World Bank and OECD, which belongs to the year 2001 to 2019.

This Master thesis has the following formation:

- Part 2 gives a literature review and historical background of the theories behind the research.
- Part 3 explains the methodology of the study and describes the used data.
- Part 4 details the synthetic control method and presents results; also, further discussion is included.
- Part 5 discusses the conclusion and gives recommendations for the countries that do not have e-Residency.

2. Literature Review

2.1. Historical Background

Estonia regained its independence from the Soviet Union in 1991, and since then, the government began its digital transformation. After the first sovereign government in 1992, ICT growth in the nation was achieving ambitious success, as a token for leaving the Soviet past behind, and as a sign for opening the Estonian culture and economy towards the West. (Kattel & Mergel, 2019)

Estonia's ID code system and its e-government infrastructure were essential to the union of e-Estonia and e-Residency. The first fundamental basis of e-Residency is the Estonian Personal Identification Code (isikukood). The innovative e-Residency idea opens Estonia's unique identification code system to non-natives who are not already in the country. (Kotka, 2015)

Another significant part in the development of e-Residency is establishing Estonia's current e-government infrastructure began with adopting the Database Act in 1997, which improved digital databases from production to maintenance (Legaltext, 1997). Besides, access to the Internet became a fundamental human right in Estonia in 2000. By the end of 2001, one of the pillars of Estonian e-government was originated, named "X-Road" which allows reliable interconnections among state information systems (e-Estonia, n.d.). The X-Road and the eID are the primary technological and theory bases of e-Residency.

In 2003, the Estonian government started an entire route to the X-Road. This e-government portal combined all-new e-services and granted a single-entry point for eID cardholders. In 2005, the Estonian Broadband Strategy indicated the development of fast Internet abilities as strategic precedence in the e-state's development because it would promote e-services (Kotka, 2015). All these improvements lead to the Estonians aged 15-74 internet usage rate of 43% at the beginning of the 21st century. (Luštšik, 2003)

Other advancements quickly arose. In 2010, the state portal was translated into English to gain Estonian e-government more convenient to non-Estonian people.

An original concept of e-Residency was introduced in 2013 by the Ministry of Economic Affairs and Communications in the 'Digital Agenda 2020 for Estonia', followed by a more detailed

implementation strategy in 2014 composed by the Ministry of Economic Affairs and the Ministry of the Interior.

In December 2015, Estonia and Finland became the first countries in Europe to acquire a shared data transfer platform based on Estonia's X-Road. This program is also used for Estonian e-Residency. (Sullivan & Burger, 2017)

In sum, since 1991, Estonia has swiftly grown and enhanced its e-government infrastructure and adding new platforms for e-Residency, which produces "transnational digital identity available to anyone in the world interested in administering a location-independent business online". (Enterprise Estonia, 2019)

2.2. Summary of the Estonian Economy

Estonia, which entered the eurozone in 2011, has a developed market-based economy and one of the more significant per capita revenue levels in the Baltics. The nation used the Estonian kroon as its currency, which significantly stabilized the economy after restoring its independence in 1991. The market mostly profits from powerful electronics, IT, telecommunications sectors and strong business relations with Finland, Sweden, Germany. It became one of the first countries in the globe to utilize a flat tax in 1994. Estonia became the country that made the most foreign investment per capita than all Central European states in the late 1990s. (Estonia Economy Overview, 2017)

"Estonia's market saw an average increase of 7% annually, which put Estonia among the fastest-growing real GDP in Europe between 2000 and 2008. Estonia recorded a significant rise in developing living norms, growing its GDP per capita from 45% on average in 2000 to 67% in 2008 of the EU27. The economic condition improved in spring 2007. The banks tightened the giving of credits, consumers' confidence diminished, and the real estate market declined. The fast growth of income persisted, but insecurity increased at the beginning of 2008, accompanied by a decrease in private consumption. Private sector investments also started to decrease, and the downward trend steepened". (Ministry of Foreign Affairs, 2014)

Estonian market is essentially affected by Finland, Germany, and Russia. Besides, Estonia operates a Scandinavian banking system that includes one of the Baltics and the region's best-determined banks.

In the OECD summary, fiscal plans have been exceptionally reasonable, which cause one of the lowest debts among the OECD countries. In the recent recovery after 2011, OECD suggests fiscal policy should be evaded, whereas increasing the real estate tax base to household real estate and higher environmental taxes could slightly support long-term spending on infrastructure and health. It would give the opportunity for cuts in labor and consumption taxes. It also mentioned that Estonia's growth is slow but stable. The viewpoint of Estonia, in general, is seen as exposed to extraneous matters, including global trade tensions. Estonia is a frontier on digitalized governmental services and already possesses several ICT unicorns; however, the OECD recommends that growth should be driven more by productivity. Another point that drew attention, which is vital for Estonia as a digitalized country, is half of the jobs at risk of computerization. Because digitalization is happening so swiftly, small firms have a hard time adopting it. Additionally, the gender gap is one of the highest within OECD countries; that's why Estonia should have an action plan to decrease these over the years. In general, Estonia's economy is carrying on strong, except that its expansion seems to be peaking and the growth is slowing down. (OECD, 2019)

In 2021, Estonia is expected to grow around 3%, depending on the healthcare situation and the restrictions. Eesti Pank anticipated that the economy will return to long-term goals by 2023, around the rate of 2.6. Even with the support measures, the country funds might continue in shortage in the following years. (Eesti Pank, 2020)

2.3. e-Government and Estonia

It is better to inspect e-Government before moving on e-Residency, which is an occurrence of it. Estonia has managed to be one of the pioneers in this field, and many nations appreciate Estonia's development in the last few years.

E-government refers to the online availability of government that hires ICT tools to deliver its responsibilities towards citizens, businesspeople, and stakeholders. OECD E-government

Project applies to the use of ICT as a mechanism to achieve better government. The UN report defined E-government as online accessibility that fulfills liabilities towards its citizens and businesses to grow services quality. Also, the OECD highlights that using ICT as a mechanism to succeed in governance is an essential tool. (e-spin, 2017)

Although e-Government has many advantages, the main ones can be listed as follows: Provides transparency and different activities and transactions between the parties. Speed up processes efficiently and faster. Checking resources and revenues quickly helps to limit corruption. Additionally, it provides more experience for the local ICT sector. (Al-Khateeb, Faloudah, Bahumayd & Zafar, 2015)

Besides, it is possible to divide the effects of e-government on the economy into indirect and direct. When we look at the indirect effects, the most important one comes to the fore its impact on administrative expenses; e-government's construction cost increases expenses while in the long run, it helps to reduce. E-governance is a fundamental alteration of traditional administrative management. In this sense, the economic influence of these IT enterprises and consultancy services will directly show the economic profits of E-government development. (Shakya, 2018)

Digitalization of government has been defined by the UN as the method of converting governance principles and interaction between society by developing digital technologies. According to a UN survey, Estonia is one of the fastest-growing nations for digitalization globally. In 2020, Estonia managed to sit in 3rd place with the state of e-Government development. The primary reason for Estonia's fast progress is the electronic identity system that allows all citizens to authenticate themselves, get access to governmental portals, and use it on private services. (United Nations. & Department of Economic and Social Affairs, 2020)

There are many types of e-Government; however, the most significant one is the Government to Business for Estonia. It includes exchanging information between government and businesses and vital for the development of small to medium firms. It plays an essential role in the progress of e-Residency while increasing the quality of communication.

2.4. e-Residency and Synthetic Control Method

The literature review's primary purpose was to analyze the influence of e-Residency on the Estonian economy. In many sources, e-Residency is labeled as an ambitious project and mentioned that it is perceived as a governmental start-up.

One of the most extensive research done by Kotka (2015), which he describes e-Residency as "not an isolated phenomenon; rather, it is the natural extension of years of experimentation with and development of Estonian e-government practices. Today, Estonia has a technological ecosystem in which almost every regular daily activity of public life provides the impetus for its transformation into an e-service." He mentions e-Residency has not occurred in one day but is a collective improvement in the ICT sector and shows that some benefits already appeared in different stakeholders. The most significant beneficiary of e-Residency for us is the Republic of Estonia. The first gains of e-Residency for Estonia were mostly associated with enhanced performance in the public and private sectors. Design refocused this plan to allow location-independent businesses for businesspeople outside the EU; thus, Estonia's apparent income model was tax gathering from companies outside the EU. Besides, he summarizes Estonia's benefits as it seeks to increase the e-Residency's ability to grow its economic size at the end (Kotka, 2015).

Sullivan and Burger (2017) state the most crucial benefit as the e-Residency facilitates commercial projects with the public and private sectors. E-Residency improves the digital identity theory to a government-backed global digitalization that can be applied worldwide for private and public sector transactions. They assert the e-Residency as the announcer of the future and figure for other nations seeking a digital program. The immense contribution to the development of e-Residency was Estonia and Finland became the first nations to originate a shared data switch platform based on Estonia's X-Road. This application allowed Estonia and Finland's databases to make e-services available to both citizens and permanent residents. (Sullivan & Burger, 2017)

In addition to Sullivan & Burger (2017), Tammpuu and Masso (2019) say usage of Estonia's e-services was first introduced in the ICT plan approved in 2006 after Estonia joined the EU in 2004. They explained the preliminary design behind the idea was inviting foreign entrepreneurs and investors by providing them exclusive entrance to the country's electronic services. Nevertheless, the e-Residency program's significant purpose has been improving Estonia's economic growth, which is restricted by its geography and population. Besides, as

Estonia is a full EU member, the e-Residency program is advertised as a digital path to the more extensive EU market. (Tammpuu & Masso, 2019)

Furthermore, in their previous article, Tammpuu and Masso draw attention to completing the e- Residency design organized by “Enterprise Estonia", the government firm whose vital goal is to improve its financial growth through expanding regional business in Estonia, which has also been the leading institution accountable for the advancement of Brand Estonia. Also, the company played an aggressive role in supporting Estonian digital nation branding. Moreover, these developments and promoting the technologically innovative notion expected to modify Estonia’s economic status and build globally exceptional fame for the small country. Further, the Estonian Parliament clarifies e-Residency aimed to contribute to Estonia’s economic development through investment activities. (Tammpuu & Masso, 2018)

Kattel and Mergel (2019) remark to Estonian economic capacity in the early 90s; it did not have significant power to build its specific IT industry; Estonia focused on more general technology development, leading to socio-economic experience to be distributed by all citizens. All these developments managed Estonia to become one of the best states in Europe in digital services (Kattel & Mergel, 2019).

Blue says that the economic shock of e-Residency in Estonia has been significant since many e-residents register corporate taxes in Estonia and do business with Estonian citizens. Additionally, more businesspeople are ready to invest in more substantial and secure digital infrastructure, bringing even more tax revenue in the future. Another future effect is compared to costly branding campaigns, e-Residency is cheaper that can attract attention and bring economic volume to the country. From a financial perspective, there can be a considerable boost for Estonian GDP and companies themselves. (Blue, 2020)

Tanel and Sandra support this idea by affirming the accelerated growth of the digital marketplace in Estonia. It also mentioned that the filing of businesses would bring Estonia investments and found new job opportunities and will thus stimulate economic growth. In this sense, it is understandable that the most beneficial e-Resident is a business-oriented person, boosting economic improvement. (Tanel & Sandra, 2015)

Tampere backs the same view by saying that Estonia is continuously looking for new approaches, which would assist the country in achieving economic prosperity and become globally known as it is done in e-Residency. E-Residency's primary benefit is seen as the possible revenue

to the Estonian economy produced by the viable businesses settled and the expanded client base for Estonian firms. (Tampere, 2015)

From a different perspective, Kimmo adds that positive country branding can guarantee a crucial economically competitive position, bringing more investment and stimulating trade with the help of e-Residency. He argues that the administration assumes e-residents can provide to the nation's economy by using Estonian banks and establishing businesses. From this viewpoint, e-Residency is also expected to increase currency stability, encourage global credibility and investor reliance. (Kimmo, 2017)

There are several articles that investigate the impact of major occurrences at the country or city level. Abadie and Gardeazabal (2003) aimed to research the economic effects of terrorist conflict in the Basque Country. Although political issues have a powerful effect on economies, quantitative evidence is rare because it is tough to measure the development of the economy without political conflicts. Therefore, Abadie and Gardeazabal introduced the Synthetic control method to estimate how GDP per capita is affected by terrorism attacks in Basque Country. This method is based on determining the effect of terrorism in Basque by comparing outcomes with a control group composed of similar non-terrorism regions. The method uses a weighted average of control units to implement a synthetic control unit. To extend this research, Abadie et al. (2010) applied the synthetic control method to a comparative case study investigating tobacco consumption in California after the tobacco control program 1988 California Proposition 99 is enacted. With Anti-tobacco legislation Proposition 99, It is raised California's cigarette excise tax by 25 cents for each packet. In the research, it was indicated that tobacco consumption in California declined considerably after Proposition 99 by using a synthetic control region. Moreover, to support inferences, a placebo test was used. Behind the logic of the placebo test is applying the synthetic control method to every single unit in the sample by including the region exposed to the intervention in the donor pool and pretending these units were exposed to tobacco control programs. Since only California was affected by the tobacco control program, when the method is applied to other units in the pool, it should not be observed tobacco consumption differed after legalization was enacted. If there is a difference in consumption, it would not be said that tobacco consumption declined due to the control program. Abadie et al. emphasized that the synthetic control method is more suitable to apply in comparative case studies than traditional regression methods for policy changes on an aggregate level.

Other authors who used the synthetic control approach developed by Abadie in their study are Billmeier and Nannicini (2013). The research analyzed the effect of economic liberalization on real GDP per capita using a worldwide sample. The liberalization period was identified as from 1965 to 2005. Counties were grouped by geographic region as sub-Saharan Africa, Asia, Latin America, and the Middle East and North Africa to build a fit donor pool. Due to the dissimilarity of subject economies, OECD countries were not included. In the paper, a different approach was used in the synthetic control method. Comparison countries pool was divided into two as type A and B experiment. While countries in the type A experiment are limited by any suitable economy in the same region of the control country, countries in the type B experiment were composed of suitable economies from the other regions. In the type A experiment, it is aimed to exclude geographically and culturally distant countries by observing the similarities between the treated and comparison countries. The aim of the type B experiment is to raise the sample size. As a result, they found economic liberalization has affected most regions such as Latin America, Asia, and the Middle East positively, except Africa.

Another study by Abadie et al. investigated the economic impact of German reunification in West Germany and chose real GDP per capita as the outcome of interest. The standard set of economic growth predictors such as per capita GDP, inflation rate, industry share of value-added, investment rate, schooling, and a measure of trade openness were used in the analysis. The results proved that reunification had a significant negative impact on the West German economy by considering GDP in capita in West Germany would be approximately 12% higher than in the absence of reunification. In addition, to measure the reliability of the outcome, the in-time placebos method was applied by reassigning treatment to another year prior to 1990. Here, the aim is to observe whether the method produces large, estimated effects when used to date before the reunification. However, it was seen reassigning the reunification period to a date before 1990 had no effect. (Abadie et al., 2015)

Similarly, Darya Lapitskaya used the synthetic control approach to research the economic impact of science and technology parks on Belarus. In the study, it was chosen post-soviet countries with similar behavior in the aspect of the economy as a donor pool. As a result of the study, it was found that the science park, which was initiated in 2015, has a significant impact on the Belarusian economy. (Lapitskaya, 2019)

On the contrary, Kaul, Klößner, Pfeifer & Schieler (2015) stated that many authors ignore irrelevant covariates when using SCM. In the paper, Kaul, Klößner, Pfeifer & Schieler (2015) proved that using all lagged values of the dependent variable as predictors makes other covariates irrelevant. To observe potential results of not combining pre-treatment values of the outcome variable, the dataset is retrieved from the research of Billmeier and Nannicini (2013). The authors have approached the synthetic control method from two different perspectives to prove this. In the first approach, only covariates and the average of the pre-intervention outcomes were involved. It is found that covariates of control units and treated units are not comparable properly. In the second run, the last pre-treatment value was also included along with the covariates group so that obtaining a decent fit. As a result, some predictors gained weight perceptibly (Kaul, Klößner, Pfeifer & Schieler, 2015).

3. Methodology and Data

To be able to observe the effect of e-Residency in the Estonian economy, it is needed to control how the Estonian economy would be different without e-Residency service by doing a comparative case study. "Comparative case studies are based on the idea that the effect of an intervention can be inferred by comparing the evolution of the outcome variables of interest between the unit exposed to treatment and a group of units that are similar to the exposed unit but were not affected by the treatment" (Abadie, 2020, p.4). Since SCM combines units, it is more beneficial than a single unit when comparing the unit subject to the intervention (Abadie, Diamond & Hainmueller, 2010). Therefore, the synthetic control method provides a systematic way to choose comparison units in comparative case studies (Abadie, Diamond & Hainmueller, 2015). In addition, SCM provides a safeguard against extrapolation compared to traditional regression methods by adjusting weights to be non-negative and sum to one. SCM helps to analyze the relative contribution of control units and how similar the affected unit and synthetic control are thanks to the weighted averages (Abadie, Diamond & Hainmueller, 2010). For these various reasons, SCM was chosen for this analysis.

The synthetic control approach developed by Abadie and Gardeazabal (2003) is one of the difference-in-differences methods and is based on the measurement of the outcome of an intervention on groups, like cities or countries. The method is used to predict what would have

happened to the treatment unit if the intervention had not occurred by observing before and after the treatment. The approach chooses weights for each control unit and uses a weighted average of groups used as controls to choose the most similar group to the treatment unit (Athey & Imbens, 2017).

The following model explains the use of synthetic control methods in comparative case study research.

$$(1)\ \widehat{Y_{1t}^{N}} = \sum_{j=2}^{J+1} w_j Y_{jt} \text{ where } 0 \le w_j \le 1\ ,\ 2 \le j \le J+1 \text{ and } \sum_{j=2}^{J+1} w_j = 1$$

There are J+1 unit, and the first unit (j = 1) is the treated unit. Therefore, J is the number of the control units. When it is assumed that data has T time period, T_0 is used the number of pre-intervention periods, and $T_1 = T - T_0$ is used post-intervention periods. Synthetic control is defined as a J × 1 vector of weights, $W = (w_2, \dots, w_{j+1})'$, which is a weighted average of the units in the donor pool. Here ${Y_{it}}^{N}$ $(i = 1, \dots, J+1\ ,\ t = 1, \dots, T)$ is the observed value of the outcome variable for region i at time t in the case of the intervention had not occurred. (Abadie et al., 2010).

In the analysis, the Synth package is used to implement synthetic control methods in R. The dataset that is used to arranged as long panel data. Columns are predictor variables, and rows are ordered first by region then by time-period. Each region in the dataset is assigned a number.

It should be inputted four matrices with X1, X0, Z1, and Z0 naming to use the synth () function. X1 includes predictor values for the unit exposed to intervention and X0 includes predictor values for the control units in the donor pool. While Z0 represents the outcome variable for the unit exposed to the intervention, Z1 represents the outcome variable for the control unit in the pre-intervention period. In the pre-intervention period, MSPE should be minimized. Dataprep () function in the synth package can be used to generate four data matrices X1, X0, Z1, and Z0 by rearranging the long panel data. A user provides predictors, dependent variable, unit numbers which indicates donor pool countries and time periods as pre-intervention and post-intervention within the dataprep () function. In this way, four generated data matrices are loaded into the synth () function. (RDocumentation, n.d.)

Table 1:
Synth package indicators

Indicator	Indicated
X1	treated predictor data
X0	controls' predictor data
Z1	treated outcome data for the pre-treatment periods over which MSPE is to be minimized
Z0	controls' outcome data for the pre-treatment periods over which MSPE is to be minimized

Source: Abadie et al., 2011

Later synth () is run to build the synthetic control unit by defining weights assigned to potential control units. To summarize and demonstrate the results synth.tab (), path.plot(), and gaps.plot() functions are used. synth.tab() is used for producing summary tables which include predictor values for the treated unit, the synthetic control unit, and all the units in the sample to able to compare. In addition, it can be listed weights for each potential control unit. path.plot() function displays the trajectories of the synthetic control and the treated unit. To observe the treatment effect, it should be seen that the treated unit and its synthetic control unit are similar before the intervention and differ distinctly after the intervention. Apart from path.plot(), gaps.plot() illustrates the difference between treated and synthetic control outcomes change in time. (Abadie et al., 2011)

In addition, with the synth.out () outputs, mean squared prediction error (MSPE) value for the pre-intervention period is obtained. This value helps to find out the average of the squared discrepancies between outcome variables of the treatment unit and in its synthetic counterpart. MSPE for the pre-intervention period is calculated with the formula below. (Abadie et al., 2010)

$$(2)\ MSPE = \frac{1}{T_0}\sum_{t=1}^{T_0}\left(Y_{1t} - \sum_{j=2}^{J+1} w_j{}^{*} Y_{jt}\right)^2$$

As Abadie and Gardeazabal (2003) suggested, a Placebo study can be applied to crosscheck the synthetic control method. Placebo test based on assigning the intervention to units where the intervention did not occur then implementing the synthetic control method. Doing this is computed the gap between the treatment unit and another unit that has not been intervened. The reason for this calculation is comparing the outcome effect of a unit similar to the treatment unit with a synthetic version of this unit without intervention. In this way, it is decided whether the gap observed for the treatment unit is due to different factors.

In order to observe the economic effect of e-Residency on Estonia using the synthetic control method, the control units should be selected among the countries without e-Residency service. Using these control units, it can be explained how GDP per capita changes in Estonia over time without e-Residency. Here, treatment is defined as the launch of e-Residency. Since Estonia is the only country that uses the e-Residency service, similar countries from the economic aspect are chosen to make a comparison. Control units were firstly limited to EU member countries. As using 28 EU member countries at once would damage the model, the second limitation was made using the classification that in the EU Economic Survey report prepared by the OECD was used. In the report, it was stated that there is an association between economic reforms and institutional quality. Accordingly, EU member countries are classified into six groups according to indicators of six broad dimensions of governance to indicate the economic outlook of members. These groups are listed as follows: Southern Europe, Central and Eastern Europe, Baltics, Continental Europe, Nordics, United Kingdom and Ireland, and South-Eastern EU countries (non-OECD). As it can be seen in Figure 1, the Baltics group that includes Estonia shares similarity to Southern Europe and Central and Eastern Europe groups. Therefore, the Southern Europe group that includes Greece, Italy, Portugal, and Spain; Central and Eastern Europe's countries that are Hungary, Poland, Slovenia, and the Czech and Slovak Republics; and certainly, Baltics might be chosen as control units (OECD, 2018). Then, Italy, Spain, and Greece are eliminated among these countries because of being considerably different from Estonia's GDP per capita. In Figure 2, selected countries' GDP per capita values by year are illustrated.

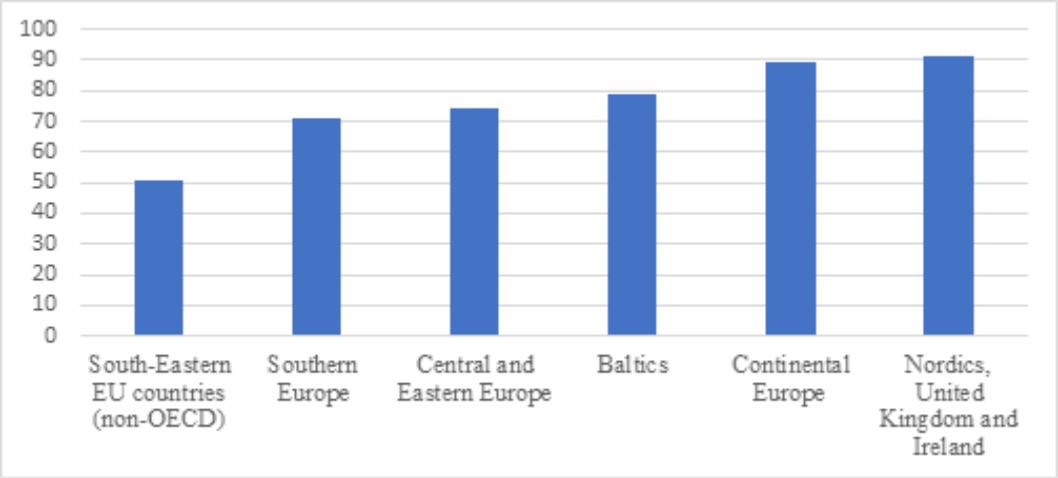

Figure 1: Worldwide Governance Indicator

Average percentile rank among all countries, from 0 (lowest) to 100 (highest)

Source: "Economic Surveys EUROPEAN UNION" by OECD, 2018, p. 76.

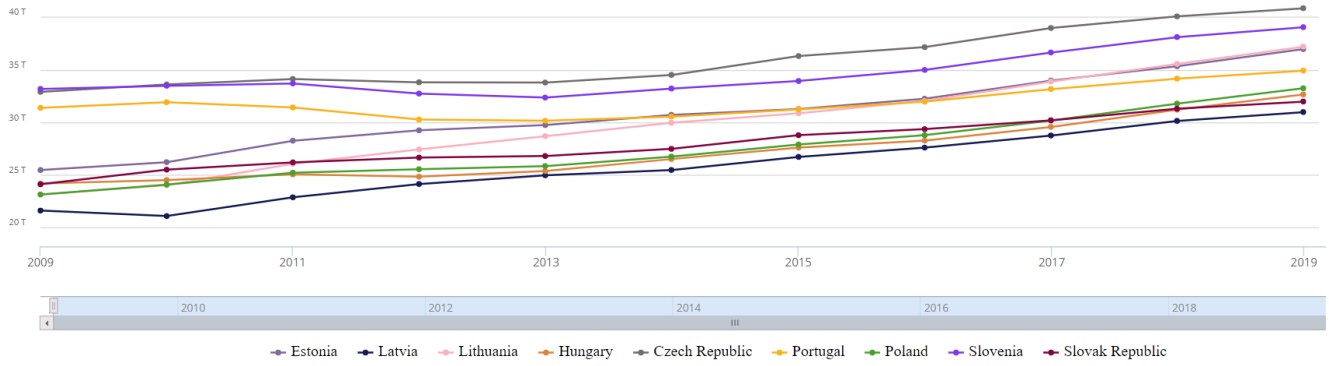

Figure 2: GDP per capita, PPP constant 2017 international $ by year for selected countries

Source: World Bank Open Data

To perform the analysis, it was gathered panel data from different data sources that include various predictors for each control country are used. These predictors were chosen with the light of Abadie's study that predicts the impact of the reunification of West Germany and East Germany on GDP per capita. Similarly, economic growth predictors were included such as the inflation rate, industry share, investment rate, schooling, and trade openness for the study. (Abadie, 2015). The outcome of interest is Purchasing Power Parity adjusted GDP per capita and is measured in 2017 international dollars. The time period is limited to 19 years, such as 15 years as pre-intervention

and 4 years post-intervention. The dataset, which belongs to the period from 2001 to 2019, was retrieved from the World Bank and OECD. As e-Residency was launched in 2014 November, the treatment period is defined as 2015 because the e-Residency effect can be observed in 2015 at the earliest. Below, it can be seen variables that will be used in the analysis, their measurement, and description. There are 47 missing values in the "ICT goods exports, % of total goods exports" variable.

Table 2:
Data Description and Sources

Variable, Measurement	Description	Source
GDP per capita PPP, constant 2017 international $ (dependent variable)	GDP per capita based on purchasing power parity. Data are in constant 2017 international dollars.	World Bank, World Development Indicators Database
Inflation, consumer prices, %	The yearly percentage variation in the cost to the average consumer of acquiring a basket of goods and services	World Bank, World Development Indicators Database
Trade, % of GDP	Trade is the sum of exports and imports of goods and services measured as a share of GDP.	World Bank, World Development Indicators Database

Industry (including construction) value added, % of GDP	Value added in mining, manufacturing, construction, electricity, water, and gas.	World Bank, World Development Indicators Database
Foreign direct investment, net inflows, % of GDP	Net inflows of investment in an enterprise operating in an economy other than that of the investor.	World Bank, World Development Indicators Database
Gross capital formation, % of GDP	Fixed assets such as land improvements, machinery, construction of roads, railways, schools, offices, hospitals, private residential dwellings, industrial buildings.	World Bank, World Development Indicators Database
Labor force participation rate, total (% of total population ages 15+) (national estimate), % of total population	The rate of the population older than 15 years who provide activity for the production of goods/services	World Bank, World Development Indicators Database
ICT goods exports, % of total goods exports	Information and communication technology assets export such as computers, communication equipment, electronic equipment and components,	World Bank, World Development Indicators Database

	and other information and technology goods.	
Upper Secondary Education, **%**	The percentage of the 25-64-year-old population with the highest-level education is upper secondary.	OECD Education Data
Tertiary Education, **%**	The percentage of the 25-64-year-old population with the highest-level education is tertiary.	OECD Education Data
Upper Secondary and Tertiary Education, %	Total percentage of the 25-64-year-old population who completed upper secondary and tertiary education.	Authors' calculation

Source: World Bank, OECD

4. Results

To use the Synthetic Control Method, the data needs to be converted to panel data. Panel data is created by collecting data from different data sources and made ready for analysis. The variables to be used and the treatment year are specified and obtained the results by using the Synth package in R. In the Table 3, weights assigned by the synthetic control method to the countries are given. According to the given weights, Lithuania, Hungary, Slovak Republic, and Poland are four countries that contributed most to the model to predict synthetic Estonia. As other countries are insignificant, their weights are shown as 0.

Table 3:
Unit weights

Unit Names	Weights
Hungary	0.234
Czech Republic	0.000
Latvia	0.000
Lithuania	0.505
Poland	0.001
Portugal	0.000
Slovak Republic	0.261
Slovenia	0.000

Source: Authors' calculations

Figure 3 is also examined to observe the outcome of the method visually. The comparison of the GDP per capita value of Estonia with the GDP per capita value of synthetic Estonia is given in Figure 3. Besides, in Figure 4, it is shown the difference between Estonia and synthetic Estonia over time. The mean squared prediction error (MSPE) value which measures lack of fit between Estonia and Synthetic Estonia for the before E-residency is 100966.1. (Abadie et al., 2015)

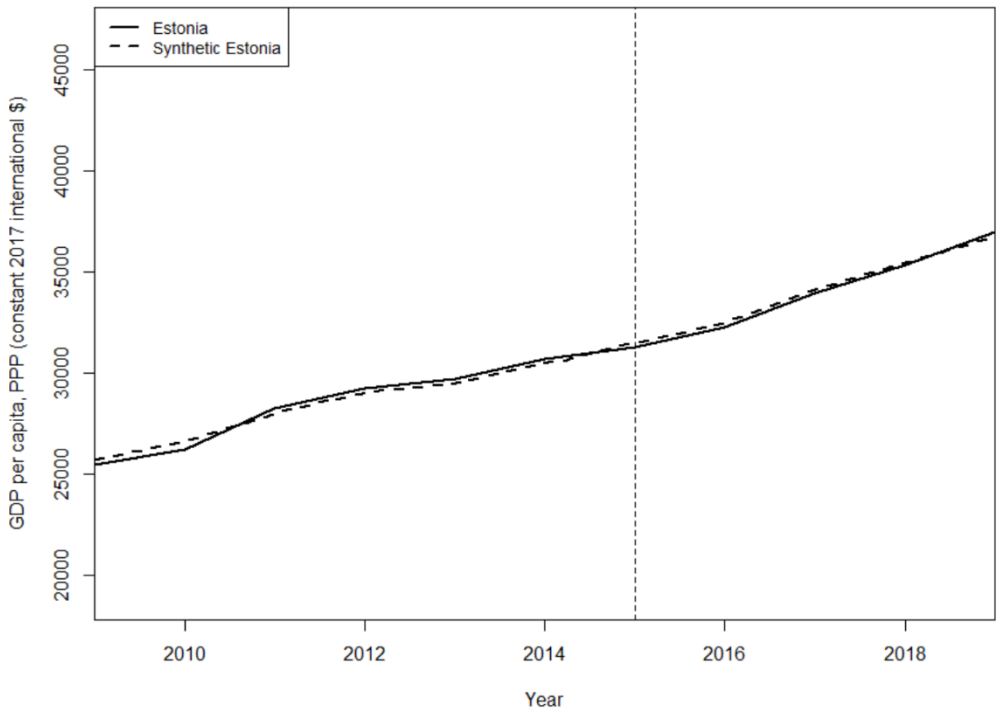

*Figure 3:*Trends in GDP Per Capita: Estonia vs. synthetic Estonia in the range of 2009-2019

Source: Authors' calculations

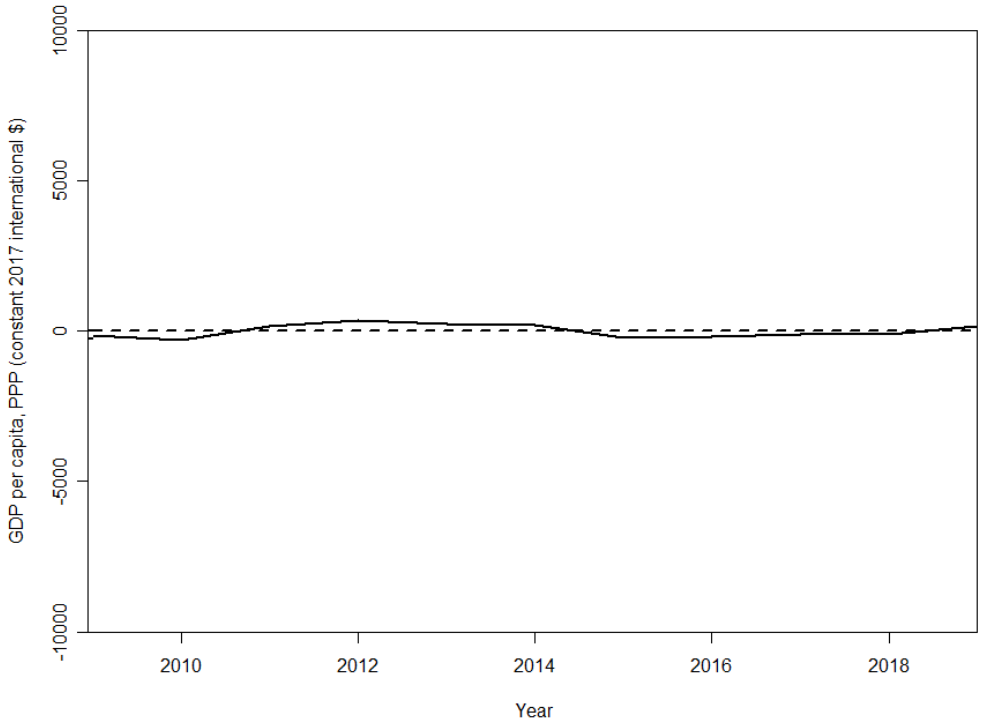

*Figure 4:*GDP Per-capita Gap between Estonia and synthetic Estonia in the range of 2009- 2019

Source: Authors' calculations

$$(3)\ MSPE = \frac{1}{T_0}\sum_{t=1}^{T_0}\left(Y_{1t} - \sum_{j=2}^{J+1} w_j{}^{*} Y_{jt}\right)^2 = 100966.1$$

The table below gives the comparison of predictors' means for Estonia and synthetic Estonia for the period prior to e-Residency. Additionally, the average of other countries in the donor pool is given in the sample mean.

Table 4:

Comparison of Predictor Means

Predictor	**Treated**	**Synthetic**	**Sample Mean**
Trade (% of GDP)	151.881	144.329	124.958
Inflation, consumer prices (annual %)	2.918	2.446	2.384
Industry (including construction), value added (% of GDP)	24.661	29. 234	26.477
Foreign direct investment, net inflows (% of GDP)	7.890	2.419	2.238
Gross capital formation (% of GDP)	24.805	21.306	21.538
Labor force participation rate, total (% of total population ages 15+) (national estimate)	61.032	58.066	57.445
Upper Secondary and Tertiary Education	89.452	92.157	81.792
ICT goods exports (% of total goods exports)	9.334	9.343	9.478

Source: Authors' calculations

In order to decide whether there is a significant effect of e-Residency on Estonian GDP or not, synthetic Estonia and Estonia should match precisely until the treatment year 2015. It can be seen in Figure 3 and Figure 4 that Estonia matches up with Synthetic Estonia before 2015. This matchup is provided in the way that the period before 2009 has been removed from the model as the rapid economic decline in 2008 has broken the model's predictive power. Furthermore, the MSPE value and difference between predictors' means for Estonia and synthetic Estonia have declined substantially compared to the model without time limitation. (See Further Discussions section for detailed information.)

However, after the treatment year, a notable differentiation is expected to prove that e-Residency changes the GDP. The conclusion that can be drawn is that e-Residency has no significant effect on Estonia's GDP.

It is essential to evaluate the predictive power of the Synthetic Control Method and its reliability. Abadie et al. used a placebo test in their study to confirm that changes started after the treatment year are not driven by another reason rather than the intervention effect. The placebo test is based on applying treatment to other units that are not actually have not been exposed to and searching for whether similar changes exist or not. This type of placebo test is named in-space placebos. Another type of placebo test is in-time placebos. In this type of placebo test, the treatment year is changed and expected not estimating significant effects when applied to the Synthetic Control Method to another year which intervention did not occur. However, in the current case, it will not give any result if an in-time or in-space placebo test is implemented to the model as it is already concluded that there is no significant effect of E-residency on Estonia's GDP. In other words, applying the E-residency service to another country in the donor pool or changing the treatment year to another year does not help measure the consistency of results. Nevertheless, robustness can be checked to observe how results are shaped and affected according to countries' weights. The robustness test is based on eliminating units with positive weights from the model and rerun the model by calculating weights each time (Abadie et al., 2015).

In the table below, the model consisting of Lithuania, Slovak Republic, Hungary, and Poland that are countries with positive weights is built and the country with the least weight removed from the model one by one. Lithuania is the country that has the largest weight in each condition as it can be expected because both Estonia and Lithuania are Baltic countries accordingly, they have similarities between their economies.

Table 5:

Unit weights of Positively Weighted Countries

Country Combination in the model	**Weights of Countries**			
Four control countries	Lithuania	Slovak Republic	Hungary	Poland
	0.505	0.261	0.234	0.001
Three control countries	Lithuania	Slovak Republic	Hungary	
	0.983	0.017	0	
Two control countries	Lithuania	Slovak Republic		
	0.983	0.017		
One control country	Lithuania			
	1			

Source: Authors' calculations

4.1. Further Discussions

In the tables below, the unit weights and comparison of predictors' means are given when the model with the same variables as the 2009-2019 time period is built for the 2001-2019 period. Based on the results, Hungary and Latvia are the countries contributing the most to this model.

Table 6:

Unit weights

Unit Names	**Weights**
Hungary	0.496
Czech Republic	0
Latvia	0.504
Lithuania	0
Poland	0
Portugal	0
Slovak Republic	0
Slovenia	0

Source: Authors’ calculations

Table 7:

Comparison of Predictor Means

Predictor	**Treated**	**Synthetic**	**Sample Mean**
Trade (% of GDP)	138.848	110.578	113.301
Inflation, consumer prices (annual %)	4.136	3.608	3.582
Industry (including construction), value added (% of GDP)	25.549	27.286	27.804
Foreign direct investment, net inflows (% of GDP)	9.740	4.557	4.877
Gross capital formation (% of GDP)	30.861	29.771	25.032
Labor force participation rate, total (% of total population ages 15+) (national estimate)	59.977	58.867	57.441
Upper Secondary and Tertiary Education	88.482	87.735	78.731
ICT goods exports (% of total goods exports)	11.915	8.241	8.732

Source: Authors' calculations

$$(4)\ MSPE = \frac{1}{T_0}\sum_{t=1}^{T_0}\left(Y_{1t} - \sum_{j=2}^{J+1} w_j{}^{*} Y_{jt}\right)^2 = 780034.9$$

Figure 5 represents both the GDP per capita value of Estonia and synthetic Estonia between 2001 and 2019 years. Moreover, in Figure 6 it is given that the difference between Estonia and synthetic Estonia over time. (See appendix)

By looking at these two graphs, it is seen that there is a considerable difference between Estonia and synthetic Estonia for the period before 2015. Furthermore, the mean squared prediction error value is significantly higher compared to the model with time restriction. The

failure in the model is due to the effects of the sharp economic decline in 2008. As it is mentioned previously, it cannot be concluded in the situation that Estonia and Synthetic Estonia do not match. For this reason, the data belong before 2009 is eliminated to obtain a more accurate model.

5. Conclusion

This research shows that e-Residency does not have a significant effect on Estonia's GDP. It proves that e-Residency in Estonia itself should not be seen as a factor that can grow GDP. In any case, the worldwide advertisement of Estonia, which was created with the additional support of the government, and the increase in the number of lately established businesses in recent years should not be ignored. In addition to these, e-Residency is essential for Estonia due to the taxes it brings, even if its effect on GDP is not significant since it is a narrow area. For further research, examining the e-government system entirely might help to show its effect on a country's GDP.

As another result of the research, the establishment of e-Residency only to contribute to GDP is not recommended to other countries. However, since the marketing and taxes it brings to the country cannot be denied, it is possible to talk about its positive effect overall. Looking at the Estonian case, it appears that e-Residency has caused fundamental changes in the country's social structure. Keeping up with the rapid development of technology and succeeding to become one of the leading countries in this regard, Estonia sets an example for other countries. Considering these, without expecting a direct impact on GDP, the establishment of e-Residency will benefit the country.

As an outcome of this research, the following suggestions can be listed for the countries that would like to find e-Residency:

1. The country to be established is strong as technological infrastructure.

2. Alteration’s in-laws and taxes for initiatives to be created for the e-Residency.

3. Determining the benefits to be provided by the state for new companies expected to be established.

4. Carrying out activities to raise awareness of the society and providing the incentives for foreign investment.

5. To continue advertising activities without waiting for immediate contribution to the economy.

Estonian comparative case shows that e-Residency cannot be a principal instrument for the country's GDP growth.

6. References

1. Abadie, A. (2020). Using Synthetic Controls: Feasibility, Data Requirements, and Methodological Aspects. *Journal of Economic Literature*. Working Paper.MIT.
2. Abadie, A., Diamond, A., & Hainmueller, J. (2010). Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program. *Journal of the American Statistical Association*, *105*(490), 493–505.
3. Abadie, A., Diamond, A., & Hainmueller, J. (2015). Comparative Politics and the Synthetic Control Method: Comparative Politics and The Synthetic Control Method. *American Journal of Political Science*, *59*(2), 495–510.
4. Abadie, A., & Gardeazabal, J. (2003). The Economic Costs of Conflict: A Case Study of the Basque Country. *American Economic Review*, *93*(1), 113–132.
5. Al-Khateeb, A., Faloudah, A., Bahumayd, M., & Zafar, A. (2015). E-Government Strategy and its impact on Economic Development of the Nation: A Case Study of the KSA. *IARJSET*, *2*(5), 105–110.
6. Athey, S., & Imbens, G. W. (2017). The State of Applied Econometrics: Causality and Policy Evaluation. *Journal of Economic Perspectives*, *31*(2), 3–32.
7. Billmeier, A., & Nannicini, T. (2013). Assessing Economic Liberalization Episodes: A Synthetic Control Approach. *Review of Economics and Statistics*, *95*(3), 983–1001.
8. Blue, A. (2020). Evaluating Estonian e-Residency as a Tool of Soft Power. *Place Branding and Public Diplomacy*.
9. Copyright Law Explained. (n.d.). *Legal Text*. Retrieved February 12, 2021, from http://legaltext.ee.
10. Definition and type of e-Government (2017). Retrieved from https://www.e-spincorp.com/definition-and-type-of-e-government.
11. Enterprise Estonia. (2019). *E-estonia*. https://e-estonia.com/solutions/e-identity/e-residency.
12. e-Residency. (n.d.). *Graph residents over time, E-Residency*. Retrieved February 11, 2021, from https://e-resident.gov.ee/dashboard.

13. Estonian Economy and Monetary Policy 1/2021. Eesti Pank. (2021). Retrieved from https://www.eestipank.ee/en/publication/estonian-economy-and-monetary-policy/2021/estonian-economy-and-monetary-policy-12021.
14. Estonian Economy Overview | Ministry of Foreign Affairs. (n.d.). Retrieved March 5, 2021, from https://vm.ee/en/estonian-economy-overview.
15. Hoe, W. (2017). *E-stonia: One Small Country's Digital Government Is Having a Big Impact Government Innovators Network.* Retrieved from https://www.innovations.harvard.edu/blogestonia-one-small-country-digital-government-having-big-impact-x-road.
16. Kattel, R., & Mergel, I. (2019). Estonia's Digital Transformation: Mission Mystique and the Hiding Hand. In R. Kattel & I. Mergel, *Great Policy Successes* (pp. 143–160).
17. Kaul, A., Kloßner, S., Pfeifer, G., & Schieler, M. (n.d.). Synthetic Control Methods: Never Use All Pre-Intervention Outcomes Together with Covariates. *Journal of Business & Economic Statistics*, 1–34.
18. Kimmo, M. (2017). *E-Residency As A Nation Branding Case*. Tallinn University of Technology.
19. Kotka, T. (2015). Estonian e-Residency: Redefining the Nation-State in the Digital Era. *Working Paper Series*, *3*, 16.
20. Lapitskaya, D. (2019). *Causal Impact of Science and Technology Parks on Economic Growth. The Case of Belarus.* University of Tartu.
21. Luštsik, O. (2003). E-banking in Estonia: Reasons and Benefits of Rapid Growth. *Kroon&Economy*, *3*, 13.
22. OECD Economic Surveys Estonia (2019). Retrieved from https://www.oecd.org/economy/surveys/estonia-2019-OECD-economic-survey-overview.pdf.
23. Shakya, S. (2018). *The Effects of E-governance on Urban Economy: Case Study of Qingdao, China.* Tallinn University of Technology.
24. Sullivan, C., & Burger, E. (2017). E-residency and blockchain. *Computer Law & Security Review*, *33*(4), 470–481.
25. *Synth.pdf*. (n.d.). Retrieved from https://cran.r-project.org/web/packages/Synth/Synth.pdf

26. synth: Constructs synthetic control units for comparative case studies (n.d). Retrieved from https://www.rdocumentation.org/packages/Synth/versions/1.1-5/topics/synth
27. Tammpuu, P., & Masso, A. (2018). 'Welcome to the virtual state': Estonian e-residency and the digitalized state as a commodity. *European Journal of Cultural Studies*, *21*(5), 18.
28. Tammpuu, P., & Masso, A. (2019). Transnational Digital Identity as an Instrument for Global Digital Citizenship: The Case of Estonia's E-Residency. *Information Systems Frontiers*, *21*(3), 621–634
29. Tampere, T. (2015). *E-Residency – Attracting Foreign Entrepreneurs to Open Businesses in Estonia*. Tallinn University of Technology.
30. Tanel, K., & Sandra, S. (2015). Legal Impediments in the EU to New Technologies in the Example of E-Residency. *Baltic Journal of Law & Politics*, *8*(2), 71–90.
31. The Economic context of Estonia—Economic and Political Overview—Nordea Trade *Portal*. (n.d.). Retrieved March 28, 2021, from https://www.nordeatrade.com/fi/explore-new-market/estonia/economical-context
32. United Nations. & Department of Economic and Social Affairs. (2020). *United Nations e-government survey 2020: Digital government in the decade of action for sustainable development*. United Nations, Department of Economic and Social Affairs.
33. *World Bank Open Data | Data*. (n.d.). Retrieved March 21, 2021, from https://data.worldbank.org/
34. *X-Road®* (n.d.). Retrieved February 12, 2021, from https://e-estonia.com/solutions/interoperability-services/x-road/

Abstraktne

E-residentsuse programm on aidanud asutada Eestis mitmeid ettevõtteid ja aidanud Eestit üle maailma reklaamida. Käesolevas magistritöös analüüsitakse e- residentsuse programmi mõju Eesti sisemajanduse kogutoodangule ja majanduskasvule, ja saadud hinnangute alusel tehakse soovitusi teistele riikidele e-residentsuse programmi kasutuselevõtmiseks. Analüüsis kasutatakse sünteetilise kontrollgrupi meetodit hindamaks e-residentsuse programmi mõju Eesti majandusele, nimelt konstrueeritakse selle meetodi abil Eestile kui riigile sünteetiline kontrollgrupp ehk nn sünteetiline Eesti e-residentsuse programmi mitte kasutavatest sarnastest riikidest võtmaks arvesse näiteks võimalust, et osa e-residentide poolt asutatud ettevõtteid oleks asutatud ka ilma e-residentsuse programmi olemasoluta. Analüüsis kasutatakse paneelandmeid, mis on koostatud OECD ja Maailmapanga andmebaasidest pärit muutujatest. Analüüsi tulemused näitavad seda, et e- residentsuse programm on tõepoolest aidanud viimastel aastatel asutada suurt hulka ettevõtteid, ja need asutatud ettevõtted on andnud riigile arvestatava täinedava maksutulu. Viimasele vaatamata ei peaks teised riigid viima e-residentsuse programmi ellu lähtudes ainult selle eeldatavast panusest vastava riigi sisemajanduse koguprodukti.

Appendix A

Non-exclusive licence to reproduce thesis and make thesis public

I, Berk Erkan (author's name) (date of birth: 23/01/1993), and

I, Demet Tasar (author's name) (date of birth: 30/11/1993),

1. herewith grant the University of Tartu a free permit (non-exclusive licence) to:

1.1. reproduce, for the purpose of preservation and making available to the public, including for addition to the DSpace digital archives until expiry of the term of validity of the copyright, and

1.2. make available to the public via the web environment of the University of Tartu, including via the DSpace digital archives until expiry of the term of validity of the copyright,

Is There a Significant Effect of e-Residency on Estonia's GDP?, (title of thesis)

supervised by Mustafa Hakan Eratalay, (supervisor's name)

2. We are aware of the fact that the authors retain these rights.

3. We certify that granting the non-exclusive licence does not infringe the intellectual property rights or rights arising from the Personal Data Protection Act.

Appendix B

Graphs with Results

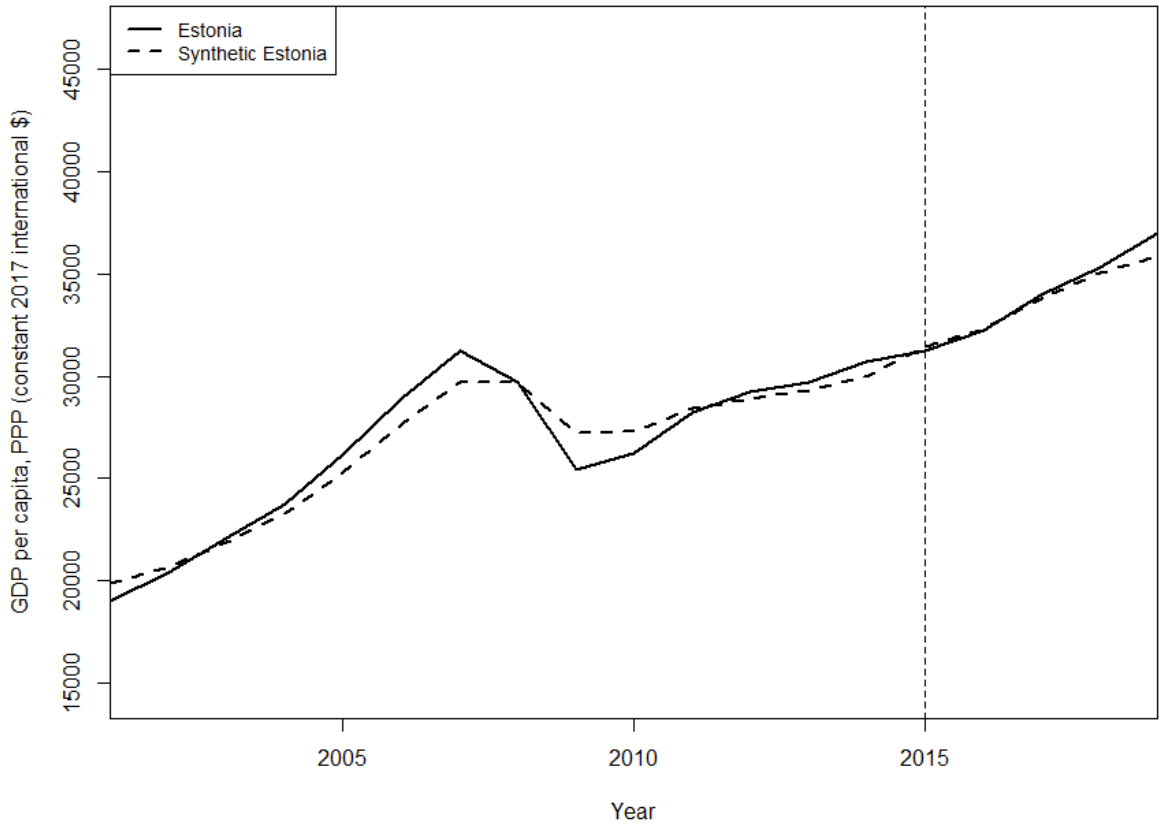

Figure 5: Trends in GDP Per Capita: Estonia vs. synthetic Estonia in the range of 2001-2019

Source: Authors' calculations

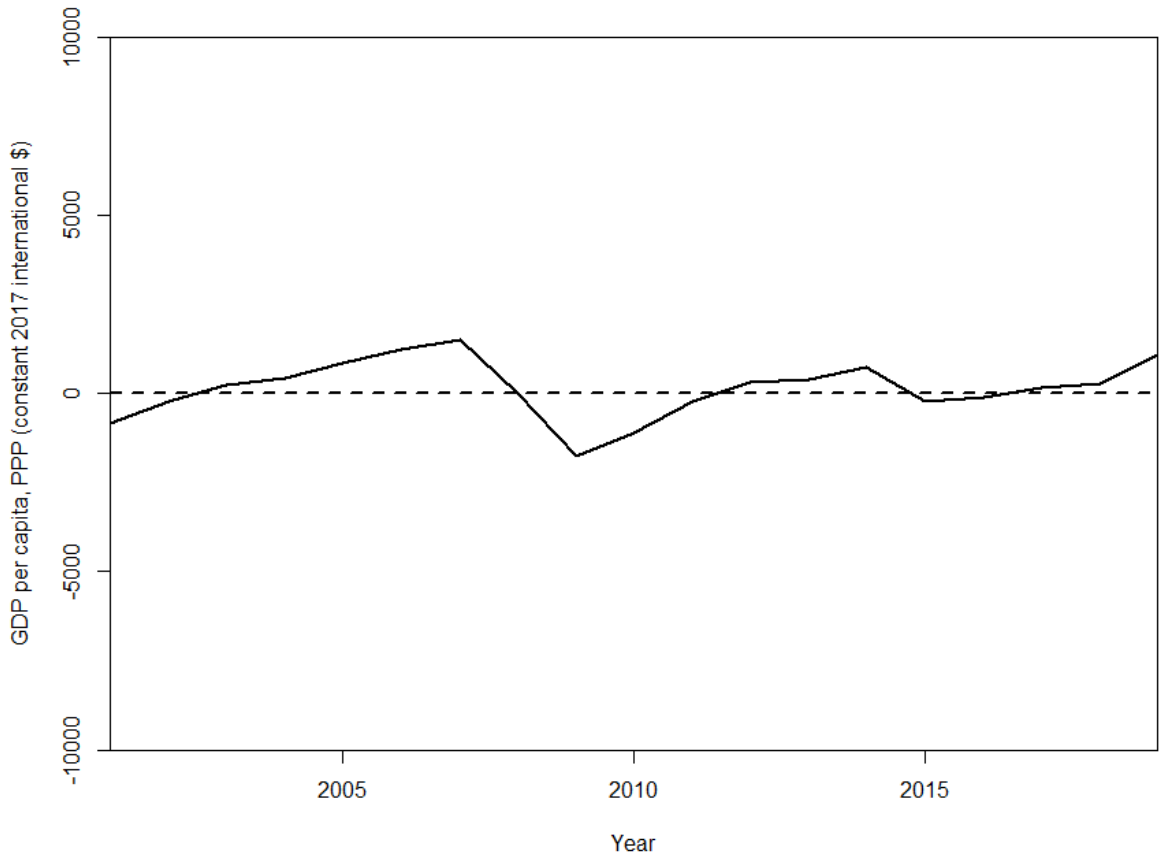

*Figure 6:*GDP Per-capita Gap between Estonia and synthetic Estonia in the range of 2001-2019

Source: Authors' calculations