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Does internet voting in Estonia affect voter turnout?

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Abstract

Internet voting has been an option to traditional voting in Estonia since 2005, which allows for a study to detect a potential effect of this new voting method on voter participation. This study aims to examine this effect by using a difference-in-difference model, where the treatment intensity in Estonia's counties the period before the implementation is compared to the treatment intensity in the period after. There is no statistically significant effect found even if the use of internet voting has increased a lot during the period investigated. This result could possibly be explained by a social bias towards specific groups that use the new voting method which are the same groups that already vote.

Key words: Difference-in-difference, fixed effects, internet voting, voter turnout, Estonia.

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Table of contents

1. Introduction.....	4
1.1. Background.....	6
2. Literature Review	8
3. Theoretical Framework	12
3.1. Hypothesis.....	13
4. Data and Methodology.....	13
4.2. Data	13
4.2.1. Dependent variable and independent variable of interest	14
4.2.2. Control variables	15
4.3. Methodology	17
4.3.1. Model	17
4.3.2. Predicted values	18
5. Results and Analysis	20
6. Robustness Checks	22
7. Conclusions.....	26
References.....	28
Appendix.....	30

1. Introduction

During recent years there has been a decrease in the voter turnout in most developed countries (OECD, 2011). If too few people vote in elections their legitimacy becomes threatened. The votes of the people can be viewed as aggregate preferences for policies. The aggregated preferences will lead to different policies, which will have an effect on economic outcomes. The issue of the decrease in voter turnout rates is therefore of importance in the field of economics, and has been reviewed mainly in the field of political economics. In the light of the decreasing voter turnout in many developed countries it is important to try to assess what might affect voter turnout.

One potential factor that might affect voter turnout is the cost of voting, which could be monetary or non-monetary, for instance gas expenses for driving to the polling station or time away from leisure. According to economic rational choice theory by Downs (1957), the individual's utility is affected positively if the cost of something (here voting) is decreasing, and hence the number of individuals voting should increase. One potential way to decrease the cost of voting is through using electronic voting. Estonia is a world leading country when it comes to internet voting and the first country to introduce internet voting in both the local, general and European parliamentary elections. They established a system where the voters can choose to vote via the internet or use the classical voting approach and vote in the polling stations. This thesis investigates a potential effect that the introduction of internet voting in Estonia might have had on voter turnout. The research question that this thesis aims to answer is *"Does internet voting in Estonia affect voter turnout"*.

Several papers have examined the use of new voting techniques, for instance postal voting and electronic voting, to enable voting and potentially affect voter participation. Most studies show that the new voting techniques leads to an increase in, or no effect on, voter turnout. There are two paper that investigate electronic voting in Estonia to see whether it affects voter participation or not. Vassil and Weber (2011) and Bochsler (2010) investigate the effect of the first Estonian general election where internet voting was optional. Bochsler uses both individual and municipal level data, and adopt a multinomial logit model and a Goodman regression model respectively. Bochsler finds that internet voting mostly fails to

attract new voters and that it is the existing voters that adapt the new voting method, but can see a small positive effect on the voters that live far from a polling station. Vassil and Weber construct a model that explain why internet voting display a bottleneck effect and does not have a large impact on voter participation. They adopt a multinomial probit model to model the choice between non-voting, conventional voting and e-voting. They distinguish between usage and impact of internet voting, and find that the use of internet voting mainly targets the existing voters while the impact of internet voting reaches the peripheral citizens.

The usage of internet voting is not equally distributed in the society, which leads to a small impact of the new voting technique (Bochsler, 2010; Vassil and Weber, 2011). In the light of this argument, this thesis wants to investigate more recent years where internet usage is more widespread and might be more equally distributed, and hence the impact might be larger. The main contribution is therefore to not only examine the general election in 2007 but use a longer time period. Furthermore, both local and general elections are used together with an alternative method. Local and general elections are used to examine a potential effect of the different types of elections. An alternative method is adopted both to the nature of the data used and since there are disadvantages of Bochsler's and Vassil and Weber's studies which intrigues the question whether an alternative approach leads to different findings.

This thesis applies a difference-in-difference method. The period before the first election using internet voting is compared to the period after, and the difference in treatment intensity between the Estonian counties are compared to each other. Treatment intensity is measured through the variation in internet usage in different counties at different times. Internet usage is used to detect the possibility to vote via the internet, and is hence a measure of how widespread the possibility of receiving the treatment is in different counties at different times. County panel data is used, and the time period 1999-2015 is examined. Data on voter turnout and internet voting is collected at the National Electoral Committee

(2016) and brought together as a data set with data on internet use and control variables from Statistics Estonia.¹

This thesis finds that there is no effect of internet voting on voter turnout, even if the use of internet voting has increased during the time period. The reason could be that the voters that already vote choose to use the new voting approach but it fails to attract new voters. This study finds that females vote in greater numbers than males, and that local elections attract less voters than general elections.

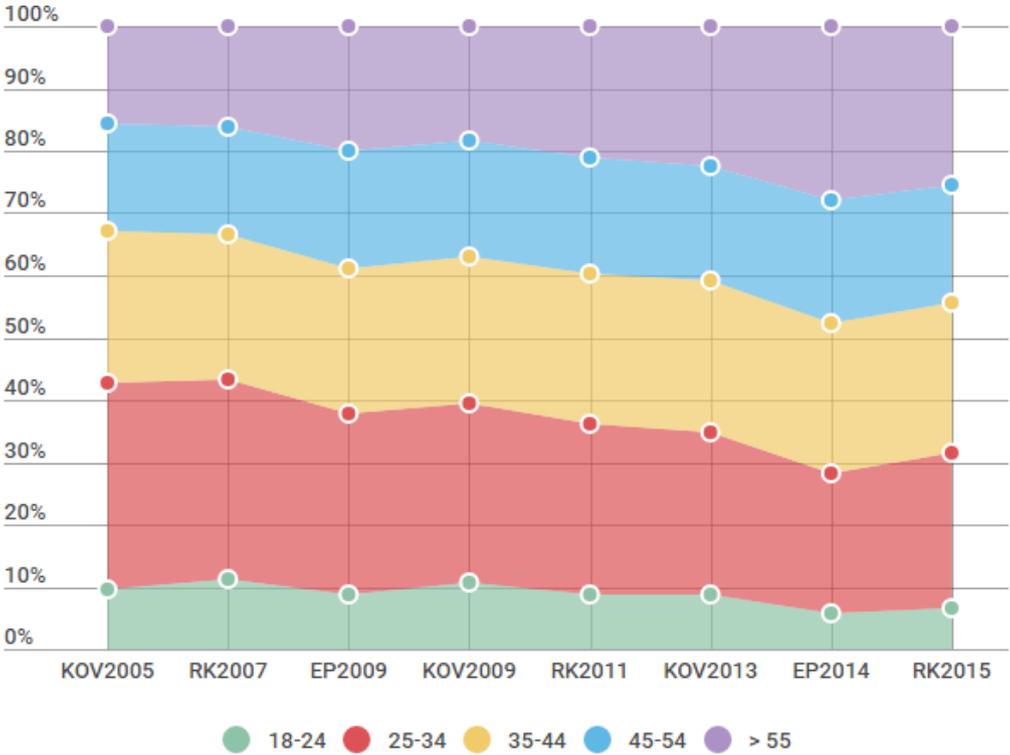
1.1. Background

In the 2005 local election, the Estonian population could for the first time choose if they wanted to vote via the internet or the traditional way in the polling station. The Estonians have since then had the opportunity to use internet voting in all general and local elections, and even in the European parliament election. This makes Estonia the first country to use internet voting in both general, local and European parliament elections. There has been a large increase in the use of electronic voting during the ten years that it has been optional. In the 2005 election internet voting consisted of almost 2 percent of the total votes, while in the latest election in 2015 around 30 percent of the voters used internet voting (Estonian Electoral Commission, 2016-b). The benefit of using internet voting is that it is convenient for the voters, especially those who live abroad or for other reason have troubles going to the polling station, it has the potential to increase voter turnout, and in the long run it will save costs from using less paper ballots. Criticism against the internet voting has mainly focused on the security of the system and that vote buying and forcing or affecting someone to vote differently than they intended might increase. The problem with vote buying and forcing or influencing someone else vote is addressed by giving everyone the chance to change their vote upon the Election Day (Estonian Electoral Commission, 2016-a).

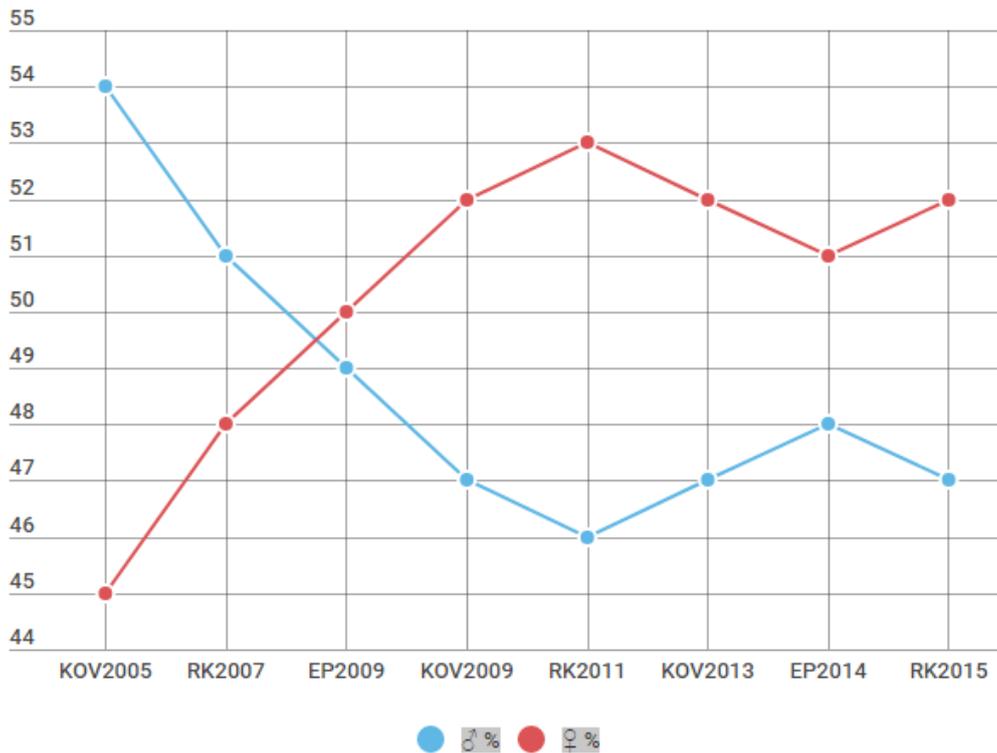
The Estonian Electoral Commission (2016-b) also provides numbers on how the internet voting is distributed among age groups and genders during 2005-2015. The graphs below

¹ See Statistics Estonia (2016-a), Statistics Estonia (2016-b), Statistics Estonia (2016-c), Statistics Estonia (2016-d) and Statistics Estonia (2017).

show that the distribution is unequal between genders and age groups, but also that there are differences in internet voting over time. The graphs display how the internet voters is distributed by gender and age. The proportion of the internet voters in the age group older than 55 years increases over time, while the proportion of internet voters in the other age groups decreases over time (graph 1). There is an even distribution between the genders, but there is a pattern where in the earlier elections the proportion of male internet voters is larger and in the later elections the proportion of female internet voters is larger (graph 2). The figures provided by Estonian Electoral Commission (2016) do not take into account that the age groups and genders might be of different proportions. However, they provide the insight that there are differences in internet voting regarding age and gender, and differences over time.



Graph 1: Age distribution between e-voters. Source: Estonian Electoral Commission (2016-b).



Graph 2: Gender distribution between e-voters. Source: Estonian Electoral Commission (2016-b).

2. Literature Review

Before electronic voting, or even pilots with electronic voting, was conducted postal voting has been used to increase voter participation by enabling voting and decreasing cost of voting. A prominent country when it comes to enabling voting and trying to increase voter participation through new voting techniques is Switzerland. Luechinger et al. (2007) conduct a study to assess whether the use of postal voting in Switzerland increases voter turnout or not. They use data for the period 1970-2005 and take advantage of the fact that postal voting was introduced in different cantons at different times. They argue that they can control for time-, issue and canton specific effects by using this long time period where different cantons were exposed to the implementation at different times. The method used is a fixed effects approach and canton fixed effects, canton specific time trends, ballot fixed effects and time fixed effects are controlled for. The control variables are GDP per capita, population and fraction of the population over 65 years and thereby control for income, population and age structure of the cantons, which further capture differences between them. They found that postal voting led to an average increase in voter participation by 4.1

percent. The effect is not gradually increasing or decreasing over time, but rather constant over time. There is no effect found of the control variables on participation. The method adopted in this thesis is similar to that of Luechinger et al., since panel data will also be used in this thesis.

Norris (2005) investigates a pilot program in the 2003 local election in the UK, where 6 million citizens in 59 local elections had the possibility to vote using the internet, using postal voting or the traditional voting approach in the polling station. She believes that the study is important since the voter participation is lower among the younger citizens who are more comfortable using online services, and hence electronic voting could be a way of approaching the younger voters. The adopted method is a logistic model and control for gender, race and class. She finds that the program led to an increase in voter participation by 15 percent. However, the effect of postal voting on voter participation is larger than the effect of internet voting. Norris concludes that postal voting is more efficient, but also cheaper and easier to administer. The effect of age on participation was consistently significant throughout her regressions and confirmed that the older citizens voted in larger extent than the younger. The effect of age was smallest in the regression including electronic voting. Postal voting mainly target the older citizens while internet voting target the younger citizens, but since postal voting is more efficient is might be a better approach even if it targets a group that display high voter participation.

The first time that part of the voters were able to vote using the internet in a binding decision on national level were in the 2004 referendum in Switzerland where 20 000 citizens were offered possibility to vote via the internet. Trechsel (2007) bases his study on this referendum, and a survey which over 1 000 of the non-voters, postal voters, e-voters and voters at the ballots answered. The model include socio-economic variables such as age, gender, education, income but also ICT-variables such as computer literacy, internet connection, and trust in communications over the internet and in the e-voting process. He finds that where postal voting is established e-voting does not increase voter participation, but rather change the voting behavior from postal voting to e-voting. There is an effect of the socio-economic variables on voter participation, but it disappears when the ICT-variables are included. The reasoning is that previous literature focus too much on the socio-economic

factors when it actually is more important to address ICT-related factors. It is an interesting finding, but it seems likely that the ICT-variables and socio-economic factors are correlated and that the effect could be captured by the socio-economic factors instead of the ICT-variables.

There has been a few studies on the case of internet voting in Estonia. Bochsler (2010) compares the voter turnout in the last general election not using internet voting (in 2003) to the first general election using internet voting (in 2007). He uses data on individual and municipal level. The control variables used on the municipal level are tax revenues per capita, ethno-linguistic composition and economic sectors, and on individual level they are age, gender, education, income and ethno-linguistic identity. He adopts a Goodman regression model to investigate the municipal data, and a multinomial logit model to examine the individual data. The Goodman regression model is an OLS model that is adopted for aggregated variables. Bochsler finds that internet voting does mostly attract the people that would have voted anyway, and that it does not decrease inequalities in voter participation, but that it could help the voters that live far from a polling station to participate in the election. The survey that the individual data is based on did not ask the respondents about their voting behavior in the previous election, which is a disadvantage of the study since it does not provide information about the pattern of the individuals' voting behavior. Bochsler's paper is unpublished but should be mentioned due to the similarity in topic.

Vassil and Weber (2011) also examine the 2007 general election in Estonia. The study is based on individual data from two surveys; one representative population survey and one online survey of e-voters. The selection of the respondents in the population survey were random, while the respondents in the e-voters survey were reached by advertisements and e-mails. A multinomial probit model is adopted to model the choice between non-voting, conventional voting and e-voting. The model explains why internet voting display a bottleneck effect and does not have a large impact on voter participation. They distinguish between usage and impact of internet voting, and find that the use of internet voting mainly reaches the existing voters while the impact of internet voting reaches the peripheral citizens. The model that examine the usage of internet voting includes the variables age,

income, gender, education and urban or rural settlement. The model that examine the impact includes political activity, political efficacy, user friendliness and computer literacy. Possible limitations of this study is that there could be demographic non-representatives and self-selection bias due to the nature of the surveys. The disadvantages of this method raises an interest in investigating the same topic by using another method.

There are different findings of the effect of socio-economic factors on voter participation, but previous literature seem to argue that socio-economic factors are important to include since the distribution of the voter participation, as well as electronic voting, are socially biased. Norris (2001) concludes that younger, wealthier, males and higher educated use internet in greater extent than other groups. It is therefore more likely that these groups also participate in internet voting than other groups. Older people, males, higher educated and wealthier are the groups that participate most in voting (Gallego, 2007; Dalton, 2006). Therefore, it could be questioned whether new voting methods target new voters or the existing voters. Both Bochsler (2010) and Vassil and Weber (2011) argue that the usage of the new technology is not equally distributed in the society, which leads to the small impact of the new voting techniques. In the light of this argument, this thesis wants to investigate more recent years where internet usage might be more equal distributed and hence the impact could be larger. Data from the World Bank Database (2017) shows that internet use on country level has increased from 66.2% in 2007 to 88.4% in 2015. This large use of internet in recent years suggests that there should be a more equal distribution of internet use in the recent years.

The main contribution is that a longer time period is investigated compared to previous research, and thereby allows to study a period where internet usage is more widespread and probably more equally distributed in the society. This study also investigate both local and general elections, which might provide an answer to whether there is a difference in voter participation between them. Furthermore, an alternative method is used. This thesis adopts a difference-in-difference model with fixed effects, partly due to the nature of the data and partly because there are drawbacks of the methods adopted in previous literature investigating internet voting in Estonia and hence it is of interest to see whether an alternative method leads to different findings.

3. Theoretical Framework

Previous literature refers to the rational choice theory by Downs (1957) to explain why enabling voting should increase voter participation.² The rational choice theory explains the decision making of individuals, where the individual will make decisions based on his preferences to maximize his utility. The rational choice theory is based on the assumption that the individuals are rational and make rational decisions.

$$P * B - C > 0$$

The benefits associated with voting (B) multiplied by the probability (P) of receiving the benefits minus the costs (C) should be larger than zero for the individual to choose to vote. The cost of voting is time spent away from leisure or work to get information about the election and to vote, but it could also be monetary costs such as gas expenses for driving to the polling station. The cost of voting should therefore decrease by the introduction of internet voting. The individual increases the chances of his preferred policies and economic outcomes if he votes, but if his vote is not the decisive vote there is no reason for him to vote since he will not affect the outcome. In a large electorate, P and hence also $P * B$ goes toward zero, i.e. the likelihood that one individual's specific vote determines the election outcome is very small. By the prediction of this model, voting should not be beneficial for almost anyone.

There are other explanations for why people choose to vote. Carlsson and Stenman (2009) looks into reasons why people vote even though their specific vote might not be significant. They conclude that there are three main reasons to why people vote; to affect the outcome, to express their opinion and because there is a social norm that there is each individual's obligation to vote. Accordingly, the model needs to capture this other factor, that voting provides an extra utility (D) even if it does not affect the outcome. An extension of the rational choice theory includes this extra utility.

$$P * B + D - C > 0$$

² Luechinger et al. (2007) and Trechsel (2007) refer to the rational choice theory.

The benefit multiplied with the probability of receiving this benefit, plus this extra utility, minus the cost need to be larger than zero for the individual to be willing to vote. The magnitude of D and C (and partly P and B) will decide whether the individual choose to vote or not, and the magnitude of these factors are individual specific. The cost of voting is, according to this model, an important factor to whether people choose to vote or not. If the cost of voting decreases by the introduction of internet voting, the voter turnout should increase by the predictions of this models. For some individuals the extra utility from voting is not larger than the cost even when internet voting is introduced and hence they will not vote even if the cost decreases. (Downs, 1957).

3.1. Hypothesis

The outcome of this study should, according to the model by Downs, depend on the magnitude of the costs and the benefits of voting. It is difficult to say whether the decrease of the costs associated with internet voting is large enough for the benefits to be larger than the costs. However, it seems likely that for some individuals the reduction of costs associated with internet voting will be large enough for them to choose to vote when they should not have voted if internet voting was not introduced. The hypothesis is therefore that the introduction of internet voting will lead to increased voter participation.

4. Data and Methodology

4.2. Data

Panel data over voter turnout in Estonia for the time period 1999-2015 is examined. The panel variables are the fifteen counties in Estonia, and the time panel variables are the fourteen election years during the time period 1992-2015. There were 7 local elections and 7 general elections during this period. The local elections were held in 1993, 1996, 1999, 2002, 2005, 2009 and 2013. The general elections took place in 1992, 1995, 1999, 2003, 2007, 2011 and 2015. The local election in 1999 occurred 6 months after the general election in 1999, and they are therefore treated as different years when setting the data as panel data. This means that there are 210 observations in the sample when all data is non-missing. Data

on some of the variables only exists for shorter time periods, and hence the time period examined is shorter when they are added. The longest time period examined is 1992-2015, and the shortest is 2002-2015. There is no missing data in the sample except for that shorter time periods are forced to be used when some of the variables are added, which means that the data set is strongly balanced. It would be preferred to use more observations to easier detect significant effects and hence municipal level data might be preferred. However, most of the control variables do not contain data on municipal level and most importantly, neither does internet usage.

The main data is collected at National Electoral Committee (2016) and contains information on voter turnout and internet voting. Data on internet usage by county is retrieved from Statistics Estonia (2016-a). Data on internet usage on country level is retrieved from World Bank Database (2017). County level data is used to be able to control for the dynamics of the voters. The control variables are retrieved from Statistics Estonia. The control variables contain information on socio-economic factors of the population and welfare of each county for the time period. The control variables from Statistics Estonia are GDP per capita (2016-b), income (2016-c), age, gender and population size (2016-d), and education (2017).

4.2.1. Dependent variable and independent variable of interest

All variables are divided by the size of the population or the size of the population that is eligible to vote in order to account for population size or size of the population that is eligible to vote. The dependent variable, voter turnout, is calculated as the percent of the eligible voters that voted. The independent variable of interest is internet usage for the period after the implementation. Internet users is calculated as the percent of the population aged 16-74 that uses the internet. Statistics Estonia started retrieving data on internet users on county level in 2005, and hence data only exists for the period after internet voting was introduced. The absence of data on internet use is solved by predicting internet use for a longer period (which is addressed in the methodology section). Predicted internet users is partly based on internet usage data on country level. Country internet users contains information on the internet users as percent of the total population for the whole country. Internet voters is not included in the regressions, but included in the data

description to get an idea of the subject of the thesis. Internet voters is calculated as the percent of the voters that voted using the internet.

VARIABLE	NUMBER OF OBSERVATIONS
Voter turnout	210
Internet users	90
Country internet users	210
Internet voters	90

Table 1: List of variables.

There is a strong correlation between voter turnout, internet voters and internet users, which reinforces the use of internet users as a measure of treatment intensity and investigating the stated research question (table 7 in appendix). Graphs 3-6 (in appendix) show how voter turnout, internet users, country internet users and internet voters change over time. Year 1 constitutes the election in 1992; year 2 constitutes the election in 1993 and so forth. Voter turnout varies around the mean, while internet voters, internet users and country internet users show large increases over time. By visual inspection the variable voter turnout seems to be stationary, which is reinforced by unit root tests (see table 8-11 in appendix). This means that there is no clear time trend in the dependent variable. The counties mostly follow the same patterns, but there is a difference in the magnitudes between the counties. The difference in magnitude between the counties indicates that there are county specific effects. The counties follow the country’s internet use pattern during the years 2005-2015, and it is therefore likely that the counties follow this pattern also for the time period 1992-2005 (graph 5 in appendix). However, that are some differences between the counties during 2005-2015, which indicates that there is also some difference between them in the earlier period (graph 4 in appendix). The increase of both county and country level internet users shows close to a linear relationship.

4.2.2. Control variables

Previous research, discussed in the literature review, has shown that education, income, age and gender are important factors regarding voter participation, and electronic voting. Furthermore, internet voting is not equally distributed between different age groups and genders in Estonia, which is discussed in the background section. Education is divided into three variables; below upper secondary education, upper secondary education and tertiary education. The education variables are calculated as the share of the total education. Below

upper secondary education and upper secondary education are included in the regressions, and tertiary education is excluded and therefore make up the base group. The education variables only contain data for the period 1999-2015. The population is divided into three age groups; young, middle-age and pension-age. The age group young is the population that is 20-39, middle-age is the population aged 40-64 and pension-age is the population aged 65 years or older. The age-group pension-age is excluded and hence the base group, that the other two age groups refer to. The population that is 0-19 years are excluded since they are not allowed to vote.³ The age group pension-age is created in line with Luechinger et al. (2007) whom control for the age group older than 65. The rest of the population is then divided into young and middle-age, where the groups consist of 19 and 24 years respectively.

VARIABLE	NUMBER OF OBSERVATIONS
Below upper secondary	150
Upper secondary	150
Tertiary	150
Young	210
Middle-age	210
Pension-age	210
Femalesshare	210
Localelection	210
GDP per capita	180
Income	120

Table 2: List of control variables.

The variable “Females share” is calculated as the percentage share of the population that is female. The dummy variable “Local election” is equal to one if it is a local election and zero if it is a general election. It should be an important control variable, since the voter participation has been lower in local elections than general elections. GDP per capita could be important to add since it should tell something about the welfare of the county and the wealth of the citizens.⁴ There is data on GDP per capita for the 12 latest elections. Data on average hourly income only exist for the 8 latest elections, and is therefore only used as a robustness check to see whether it is an important factor that provides more information than GDP per capita. If there is no large differences between GDP per capita and income, GDP per capita will be used due to the larger number of observations.

³ The data comes in clusters of five ages, which means that the population aged 18 or 19 is included in this group even if they are allowed to vote.

⁴ GDP per capita is used as a measure of income in Luechinger et al. (2010).

4.3. Methodology

4.3.1. Model

This thesis applies a difference-in-difference model to capture a potential effect of internet voting on voter turnout. The effect of internet voting on voter turnout is observed by comparing treatment intensity in the period before the introduction of internet voting to the period after. The period before the first election using internet voting is compared to the period after, and the difference in treatment intensity between the Estonian counties are compared to each other. In a regular difference-in-difference model is a treatment group compared to a control group. The data used in this study does not contain a treatment and a control group, but rather allows for internet usage to be used as a measure of treatment intensity. Treatment intensity is measured through the variation in internet usage in different counties at different times. Internet usage is used to detect the possibility to vote via the internet, and is hence a measure of how widespread the possibility of receiving the treatment is in different counties at different times. The idea is that if the individual does not use the internet he will not vote using the internet and hence internet use is a good way of measuring the treatment intensity.

The most important assumption that needs to be fulfilled in a difference-in-difference model is the parallel trend assumption, which means that the trend before the implementation should be the same in the treatment and control group. This means that the trend of the dependent variable should be the same, or at least very similar, in the treatment and control groups prior to the implementation, since an effect of the implementation otherwise could depend on the difference between the groups and not the implementation itself. This data does not contain one treatment and one control group, but rather different treatment intensity in different counties. Graph 7 (in appendix) display a visual inspection of this assumption. Three counties are selected based on their internet use intensity; one county with low intensity, one with average intensity and one with high intensity. The voter turnout in the low treatment intense county Jõgeva, in the average treatment intense county Järva and the high treatment intense county Harju display very similar trends prior to the implementation, which indicates that the parallel trend assumption is fulfilled. After the implementation there is larger differences between them, which could be the result of the introduction of internet voting.

$$voteturnout_{i,t} = \beta_0 + \beta_1 internetusers_{i,t} + \beta_2 interaction_{i,t} + \beta_3 X'_{i,t} + \beta_4 yeardummies_{i,t} + \beta_5 countydummies_{i,t} + u_{i,t}$$

$$interaction = \beta_1 internetusers_{i,t} * \beta_2 post_{i,t}$$

Voter turnout is the dependent variable and the interaction variable is the independent variable of interest. The variable post is a dummy variable that is equal to one if internet voting was introduced and otherwise equal to zero. The variable post is equal to zero for the first eight elections and equal to one for the last six elections. The interaction term is an interaction variable and calculated by multiplying internet users and the post treatment variable. The variable interaction is equal to zero for the period before the implementation of internet voting and contains a value for every panel for every year after the implementation. The interaction term is the treatment intensity after implementing internet voting i.e. the variable of interest. Year dummies are included to capture time fixed effects and county dummies are included to capture county fixed effects. The fixed effects approach is less efficient but more consistent than the random effects approach. The fixed effects approach is a better fit when county specific effects are expected, and as previously stated there is reason to believe that there are county specific effects. The fixed effects approach is mostly used in difference-in-difference models. Therefore are county dummies added in this model. Year specific effects is included in the base model, but other time controls will also be tested as robustness checks. Year dummies is the base model, since it allows to control for year specific effects. X'_{it} contains information on the control variables, β_0 is the intercept and u_{it} the error term. Clustered standard errors at county level are included in all regressions. Clustered standard errors are based on the assumption that there is independence in standard errors across clusters and correlation of standard errors within clusters. This approach allows for differences across counties, which is likely to exist in this data.

4.3.2. Predicted values

Data on internet users only exists for the period after the implementation of internet voting. This means that there is no data on the before period, and hence the before and after

periods cannot be compared. This problem is solved by predicting values on internet users for a longer period.

$$internetusers_{i,t} = \beta_0 + \beta_1 countylineartimetrends_{i,t} + \beta_2 X'_{i,t} + \beta_3 countydummies_{i,t} + u_{i,t}$$

The model above is used to regress internet users and predict internet users for a longer time period. The model is based on county specific linear time trends. Both the country's and counties' internet use clearly show an increasing trend, and these county specific time trends are captured by this variables. This model allows the trend to vary between the counties, since the linear time trends are county specific. It is important to also add county fixed effects to further capture differences between the counties, and other variables that can explain internet use. The problem with this approach is that it is a prediction of the reality. It could however be a good prediction of the reality since the county specific linear time trends and control variables that are likely to affect internet use are available. It could be argued whether a linear time trend is suitable or not, but both the country and the counties display close to a linear increasing trend (graph 5 in appendix).

The regression (in table 12 in appendix) show the prediction of internet users is based on. County specific linear time trends have a small, positive, significant impact on internet use, which means that the county specific time trends help explain internet use. This seems accurate since internet use display an increasing close to linear county specific time trend. Gender, age, education and GDP per capita are not significant, but they are included because they should be relevant to explain internet use and to capture differences in internet use between the counties. The R-squared and adjusted R-squared are high, indicating that the model is a good fit.

The prediction is compared to the true values of the internet users for the time period 2005-2015 (in table 13 in appendix). The prediction and the true values display very similar values, which reinforces the use of this prediction. Graph 8 (in appendix) shows the predicted values and country internet use in the same graphs. The predicted values should not completely follow the country's pattern due to county specific effects, but it seems reasonable that the

counties mostly follow the country’s pattern. The graph display the expected result. The predicted values are then changed to the true values for the period that they are non-missing (2005-2015) and the predicted values are used for the time period that they are missing (1999-2003).⁵ These partly predicted values are compared to the true values of the country internet use for the time period 1999-2015 (in table 14 in appendix) to try to assess the fit of them, and they display very similar values. As stated before, a prediction can only provide an estimation of reality and this is a disadvantage of the model used in this thesis. However, the prediction is only used for four time periods and the predictions seems like good estimations of the reality according to the comparisons between the predictions and true values.

5. Results and Analysis

Table 3 below display the result from the regression of the interaction term, predicted internet users, age, gender, GDP per capita, education, the local election dummy, year fixed effects and county fixed effects on voter turnout. The interaction term displays a small, positive, insignificant effect on voter turnout, which means that there is no significant effect of the introduction of internet voting on voter participation. The control variables are statistically insignificant, except for the gender variable and the dummy variable for local election which are statistically significant. When the number of females increases in the population the voter participation will also increase, which means that females vote in greater numbers than males. The dummy variable for local election, that is equal to one if the election is on local level, has a negative impact on voter participation, which means that voter turnout is larger in general than in local elections.

VARIABLES	The complete model Voter turnout
interaction	0.0305 (0.0610)
predictedinternetusers	-0.0340 (0.0427)
young	0.230 (0.258)

⁵ For future reference is this variable called predicted internet users, but it contains the true values for 2005-2015 and the predicted values for 1999-2003.

middleage	-0.127 (0.420)
Pensionage (omitted)	-
Femalesshare	0.883* (0.512)
GDPpercapita	4.07e-07 (2.09e-06)
Belowuppersecondary	-0.0879 (0.0804)
Uppersecondary	-0.0726 (0.0745)
Localelection	-0.0308*** (0.00539)
Constant	0.143 (0.398)
Year fixed effects?	Yes
County fixed effects?	Yes
Observations	150
Adjusted R-squared	0.82
R-squared	0.86

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3: The results from the complete model.

The insignificant effect of internet voting on voter participation could be the result of too few observations, and could possibly be solved in future research by using a larger number of observations. However, it could be the true effect that is found and possibly there is no effect of internet voting on voter turnout. It could also be the case that the effect disappears when controlling for too many factors. The use of the control variables are further examined in the robustness check section, and the result is stable even when other variations of, and other, control variables are used. Furthermore, the use of the control variables selected are supported by previous research. The robustness section also addresses the issue of what time controls that should be used, since other types of time controls lead to different results. The use of year dummies to control for time effects are supported by the robustness checks. This means that the model selected should be the most appropriate, and given that the number of observations are sufficient, there is no effect of internet voting on voter turnout

6. Robustness Checks

One of the main questions about the model is what time controls that should be used. The result changes when other time controls than year dummies are used. There is a significant effect of the interaction term when weaker time controls are adapted. The choice of time control is therefore of importance. Linear time trends are not suitable since they have a small impact, both in significance and magnitude, on voter turnout. The results without any time controls are, in fact, very similar to the results using linear time trends, which indicates that the linear time trends do not capture any time effects and that there are no linear time trends (see table 16 in appendix). Another option to use as time control is the post treatment dummy, which only controls for a difference between the period before and after the treatment. This model provides a fairly large significant value of the interaction term. The question is then, if the year dummies control for too much of the time effects and removes an actual effect or if the model with the post treatment dummy provides the wrong result since there are year specific events that should be controlled for and otherwise bias the result.

Table 15 shows a test for whether year dummies have explanatory power or not. It is a joint test that exams whether the time dummies for all years are equal to zero or not. If the null hypothesis that the time dummies are equal to zero can be rejected, the time dummies do significantly explain the model, which indicates that time dummies should be included in the model. The null hypothesis can be rejected, which indicates that year dummies should be included in this model. Hence, year specific effects have a significant effect on voter turnout and the test reinforces the inclusion of time fixed effects.

Table 4 shows the regressions including the post dummy as time control, and provides a comparison between the regression including the ten latest elections and the regressions including the eight latest elections. Looking at the models including GDP per capita, the significance and the magnitude of the interaction term disappears when fewer election years are used. It is likely that the interaction term becomes less significant when fewer observations is used. However, it seems unlikely that the significance drops from a p-value of 0.009 to a p-value of 0.408. Furthermore, it is unstable that the magnitude of the effect

drops drastically when the time period changes. The conclusion that can be drawn from this is that the results change drastically when fewer years are used, and hence it seems likely that there are year specific effects. Therefore, the model with year dummies should be a better fit than the model with the post treatment dummy as time control. The third regression includes income instead of GDP per capita and hence only the latest 8 elections. The result is similar to the second model including GDP per capita. The comparison between them indicates that GDP per capita can be used instead of income, and hence allows the model to include more observations.

VARIABLES	Model with GDP and 10 election Voter turnout	Model with GDP and 8 elections Voter turnout	Model with income and 8 elections Voter turnout
interaction	0.119** (0.0572)	0.0711 (0.0805)	0.0439 (0.0693)
predictedinternetusers	0.0242 (0.0397)	0.0704 (0.0604)	0.0272 (0.0549)
young	-0.223 (0.288)	-0.434 (0.370)	-0.225 (0.370)
middleage	-0.360 (0.448)	-0.622 (0.556)	-0.214 (0.553)
Pensionage (omitted)	-	-	-
Femaleshare	1.643*** (0.603)	2.076** (0.815)	2.223*** (0.774)
GDPpercapita	2.81e-06 (1.83e-06)	3.17e-06 (2.71e-06)	
Belowuppersecondary	-0.152 (0.107)	-0.167 (0.123)	-0.139 (0.112)
Uppersecondary	-0.0762 (0.104)	-0.112 (0.114)	-0.157 (0.111)
post	-0.0811*** (0.0259)	-0.0675* (0.0349)	-0.0715** (0.0302)
Localelection	-0.0337*** (0.00416)	-0.0276*** (0.00501)	-0.0231*** (0.00537)
averagehourlywage			0.0364*** (0.0103)
Constant	-0.0257 (0.400)	-0.0743 (0.553)	-0.476 (0.549)
Year fixed effects?	No	No	No
County fixed effects?	Yes	Yes	Yes
Observations	150	120	120
Adjusted R-squared	0.67	0.65	0.70
R-squared	0.72	0.72	0.76

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4: The models including the post dummy as time control.

These results can be compared with table 5 where the model with year dummies provides more stable results when the time period is shortened. The interaction terms are still insignificant, and display similar, slightly smaller values, compared to the findings in the result section. The first regression includes GDP per capita and the shorter period, and the second regression includes income instead of GDP per capita and hence the shorter time period. Table 5 also shows that the difference when using income instead of GDP per capita is not large. The model with GDP per capita is selected as the best fit, since it includes more observations.

VARIABLES	Model with GDP and 8 elections Voter turnout	Model with income and 8 elections Voter turnout
interaction	0.00345 (0.0674)	-0.00333 (0.0660)
predictedinternetusers	-0.0294 (0.0601)	-0.0234 (0.0587)
young	0.155 (0.322)	0.124 (0.309)
middleage	-0.240 (0.527)	-0.257 (0.518)
Pensionage (omitted)	-	-
Femalesshare	0.933 (0.611)	0.948 (0.581)
GDPpercapita	-5.67e-07 (3.09e-06)	
Belowuppersecondary	-0.114 (0.0863)	-0.117 (0.0870)
Uppersecondary	-0.102 (0.0794)	-0.0985 (0.0786)
Localelection	-0.0119** (0.00516)	-0.0119** (0.00523)
averagehourlywage		0.00284 (0.0123)
Constant	0.212 (0.507)	0.203 (0.486)
Year fixed effects?	Yes	Yes
County fixed effects?	Yes	Yes
Observations	120	120
Adjusted R-squared	0.84	0.84
R-squared	0.88	0.88

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5: Comparison between GDP per capita and income.

Table 6 provides an overview of the buildup of the model, by adding control variables. The interaction term displays stable values, which seems reasonable since the effects of the control variables are not that large nor significant in most cases.

VARIABLES	Model with one control variable	Model with two control variables	Model with three control variables	Model with four control variables
	Voter turnout	Voter turnout	Voter turnout	Voter turnout
Interaction	0.0677 (0.0569)	0.0431 (0.0563)	0.0457 (0.0566)	0.0335 (0.0583)
predictedinternetusers	-0.0261 (0.0437)	-0.0554 (0.0428)	-0.0421 (0.0420)	-0.0360 (0.0419)
Young		0.386 (0.247)	0.305 (0.253)	0.239 (0.254)
Middleage		-0.131 (0.411)	-0.110 (0.414)	-0.141 (0.410)
Pensionage (omitted)		-	-	-
Femalesshare			0.743 (0.468)	0.868* (0.491)
Belowuppersecondary				-0.0849 (0.0795)
Uppersecondary				-0.0744 (0.0741)
Localelection	-0.0307*** (0.00540)	-0.0304*** (0.00528)	-0.0307*** (0.00527)	-0.0308*** (0.00537)
Constant	0.614*** (0.0213)	0.521* (0.265)	0.135 (0.374)	0.158 (0.377)
Year fixed effects?	Yes	Yes	Yes	Yes
County fixed effects?	Yes	Yes	Yes	Yes
Observations	150	150	150	150
Adjusted R-squared	0.80	0.82	0.82	0.82
R-squared	0.84	0.85	0.85	0.86

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6: Build up of the complete mode by adding control variables..

The conclusions that can be drawn from the robustness checks are that year dummies are the appropriate time control, and that the results found are stable. The robustness checks also support the findings that females vote in greater extent than men, and that local elections attract less voters than general elections.

7. Conclusions

This study addresses the introduction of internet voting in Estonia and whether it has had an effect on voter participation or not. The issue is examined by using a difference-in-difference model where Estonia's counties are compared to each other and the period before the implementation is compared to the period after. The main contribution is that a longer time period is investigated compared to previous research, and thereby allows for a study of a period where internet usage is more widespread and probably more equally distributed in the society. This suggests that internet voting might, on the contrary to previous findings, not only attract the existing voters but rather new voters. However, the findings in this study is similar to previous literature and suggests that there is no effect of internet voting on voter participation, which indicates that the new voting technique fails to attract new voters. There is no significant effect of internet voting on voter turnout found, yet this study did find that females vote in a greater extent than males, and general elections attract more voters than local elections.

There are two main limitations with this study. The number of observations could preferably be larger and the use of predicted values might be questioned. It is possible that a significant effect could be found if the number of observations were larger, but in this master thesis the time for data collection is too scarce to investigate that. However, a similar study with more observations could be a subject for future research. Another limitation is the non-existing data on internet use on county level for the period before internet voting was introduced. This problem is solved by predicting values for four time periods. Comparisons of the predicted and true values show that the predictions are very similar to the true values, and the use of predictions should therefore not alter the results significantly.

Given that the number of observations is sufficient and that the predictions are accurate, there is no effect of internet voting on voter turnout. Electronic voting has, however, increased during the period examined. The explanation for this, provided by previous research, is that the new voting technique attracts the existing voters instead of new voters.⁶ The investigated subject is of importance due to the decrease in voter participation in most

⁶ See Bochsler (2010) and Vassil and Weber (2011).

developed countries. Furthermore, resources has been spent on introducing new voting techniques, partly with the hope that they increase voter turnout, and hence it is important to examine the effect.

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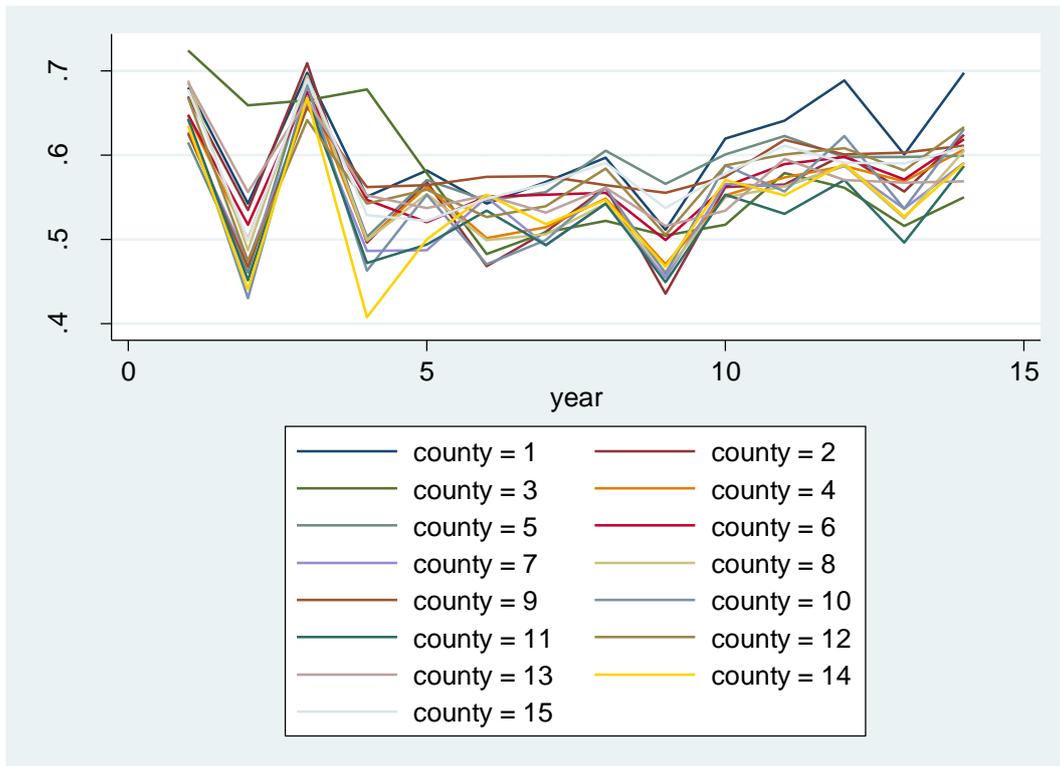
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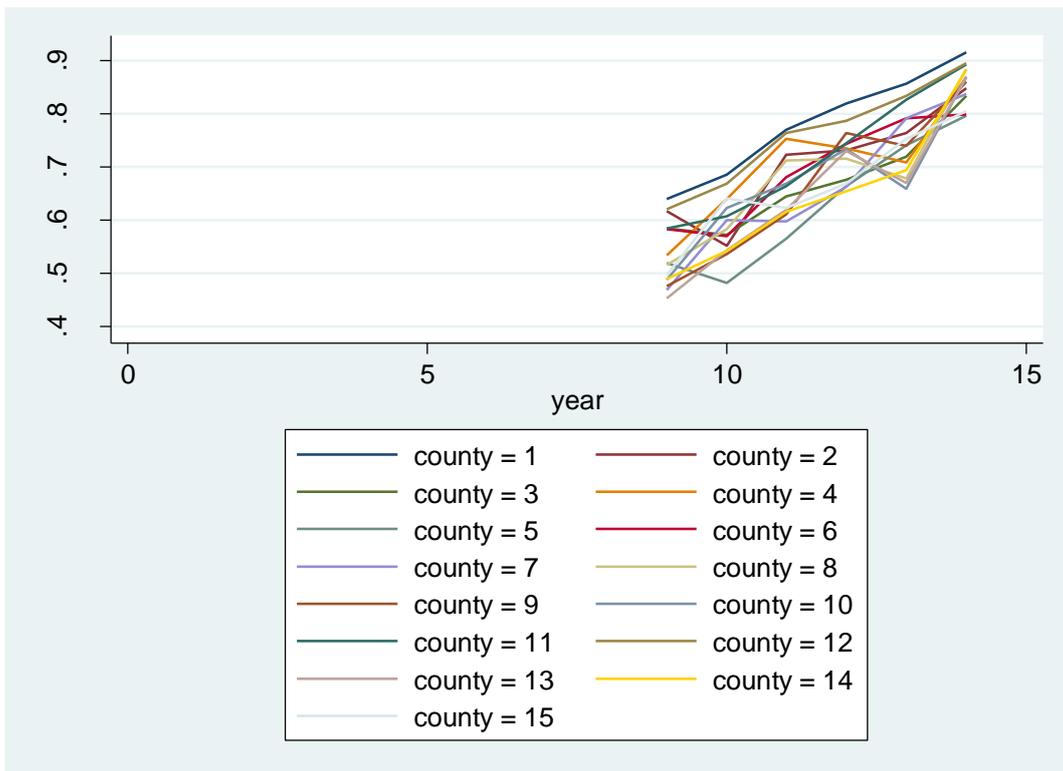
Appendix

VARIABLE	Voter turnout	Internet users	Internet voters
Voter turnout	1.0000		
Internet users	0.6290	1.0000	
Internet voters	0.5743	0.8786	1.0000

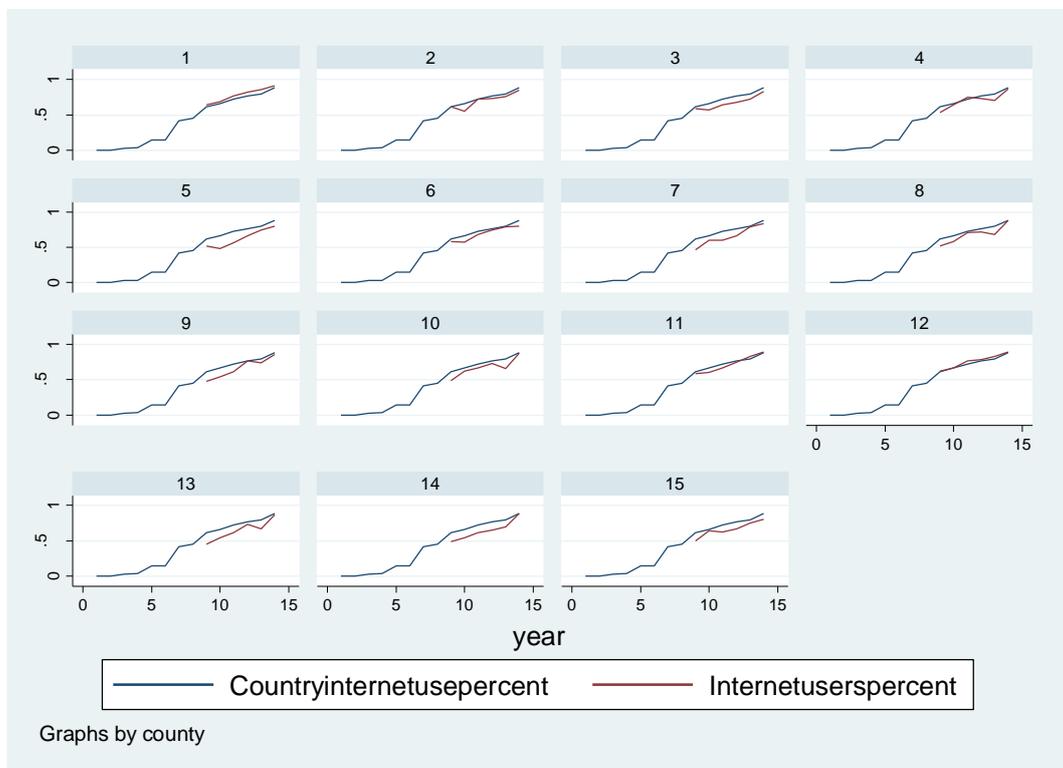
Table 7: Correlation between voter turnout, internet voters and internet users.



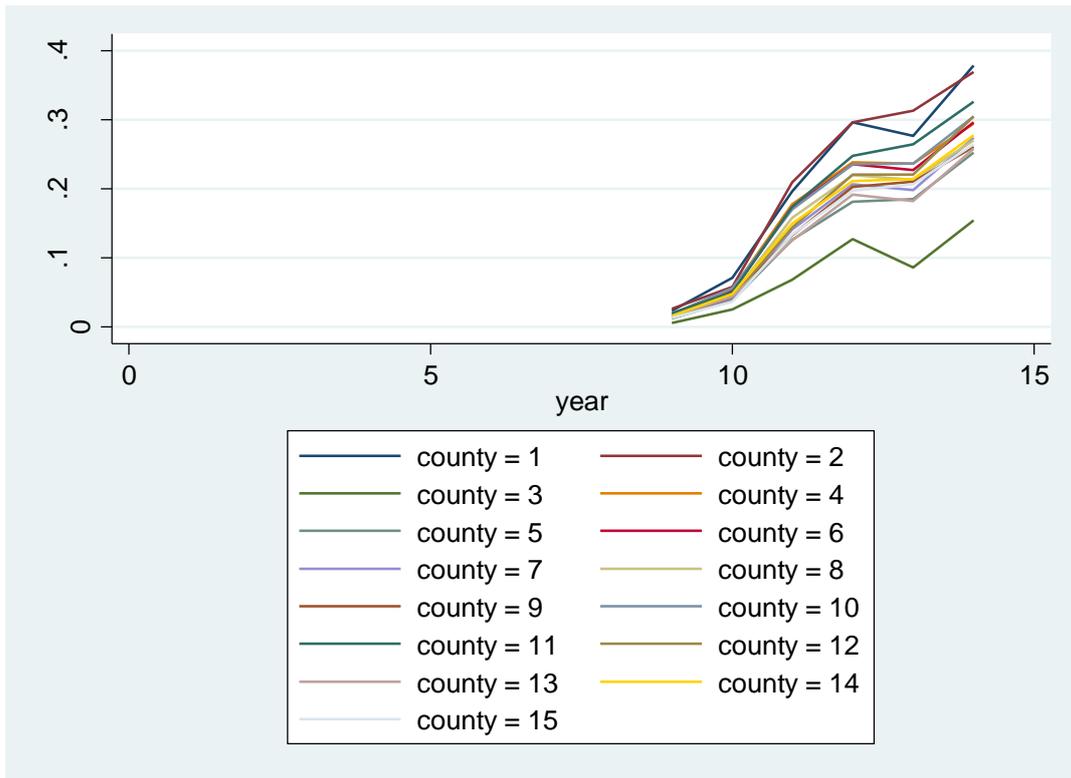
Graph 3: Voter turnout as percent of eligible voters 1992-2015. Source: National Electoral Committee.



Graph 4: Internet users aged 16-74 as percent of the total population aged 16-74 2005-2015. Source: Statistics Estonia.



Graph 5: Internet users aged 16-74 as percent of the total population aged 16-74 2005-2015 and country level internet users 1992-2015. Source: Statistics Estonia & World Bank Database.



Graph 6: Internet voters as percent of total votes 2005-2015. Source: National Electoral Committee.

Harris-Tzavalis unit-root test for Voterturnoutpercent

Ho: Panels contain unit roots	Number of panels =	15
Ha: Panels are stationary	Number of periods =	14
AR parameter: Common	Asymptotics: N -> Infinity	
Panel means: Included	T Fixed	
Time trend: Included		

	Statistic	z	p-value
rho	-0.3735	-12.5120	0.0000

Table 8: Harris-Tzavalis unit-root test.

Breitung unit-root test for Voterturnoutpercent

Ho: Panels contain unit roots	Number of panels =	15
Ha: Panels are stationary	Number of periods =	14
AR parameter: Common	Asymptotics: T,N -> Infinity	
Panel means: Included	sequentially	
Time trend: Included	Prewhitening: Not performed	

	Statistic	p-value
lambda	-4.1872	0.0000

Table 9: Breitung unit-root test.

Im-Pesaran-Shin unit-root test for Voterturnoutpercent

Ho: All panels contain unit roots	Number of panels =	15
Ha: Some panels are stationary	Number of periods =	14
AR parameter: Panel-specific	Asymptotics: T,N -> Infinity	
Panel means: Included	sequentially	
Time trend: Included		

ADF regressions: No lags included

	Statistic	p-value	Fixed-N exact critical values		
			1%	5%	10%
t-bar	-5.7670		-2.740	-2.570	-2.470
t-tilde-bar	-2.8516				
Z-t-tilde-bar	-7.8812	0.0000			

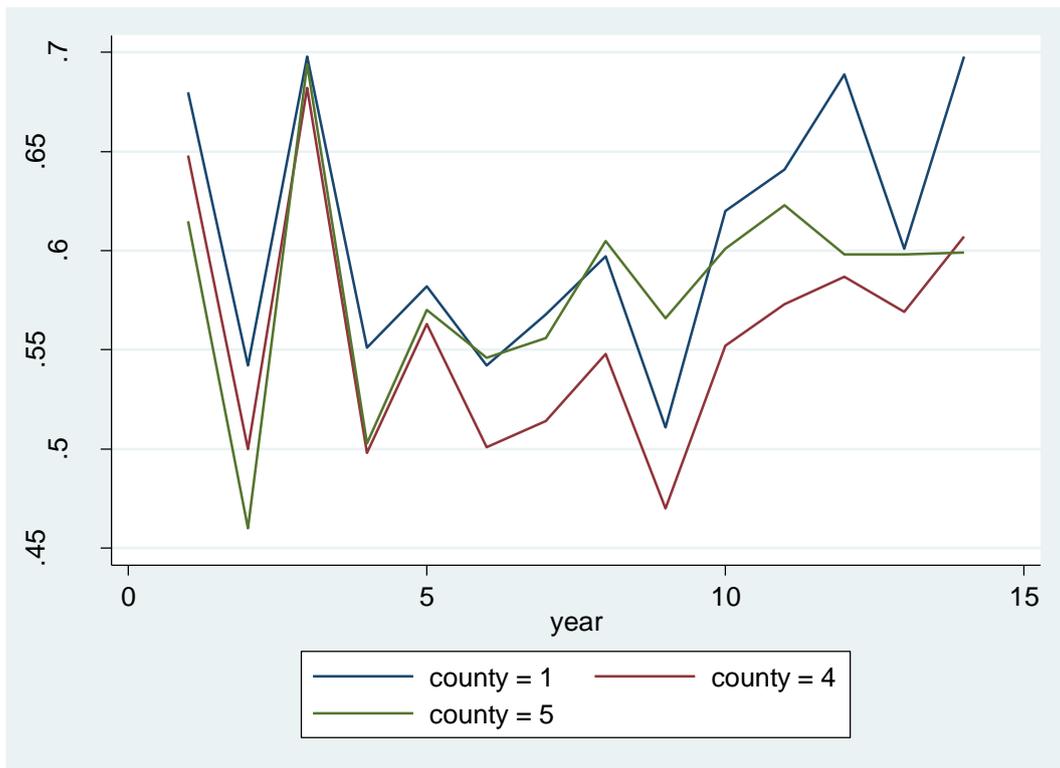
Table 10: Im-Pesaran-Shin unit-root test.

Hadri LM test for Voterturnoutpercent

Ho: All panels are stationary	Number of panels =	15
Ha: Some panels contain unit roots	Number of periods =	14
Time trend: Included	Asymptotics: T, N -> Infinity	
Heteroskedasticity: Not robust	sequentially	
LR variance: (not used)		

	Statistic	p-value
z	2.6898	0.0036

Table 11: Hadri LM stationarity test.



Graph 7: Voter turnout in the low treatment intense county Jögeva (county 5), the average treatment intense county Järva (county 4) and the high treatment intense county Harju (county 1). Source: National Electoral Committee.

Model to predict internet usage	
VARIABLES	Internet users
Belowuppersecondary	-0.399 (0.258)
Uppersecondary	-0.368 (0.274)
young	-0.713 (1.149)
middleage	-1.756 (1.341)
Pensionage (omitted)	-
Femalesshare	-0.419 (2.374)
GDPpercapita	-6.38e-06 (5.67e-06)
lineartimetrend1	0.0568*** (0.0114)
lineartimetrend2	0.0371** (0.0140)
lineartimetrend3	0.0565*** (0.0119)

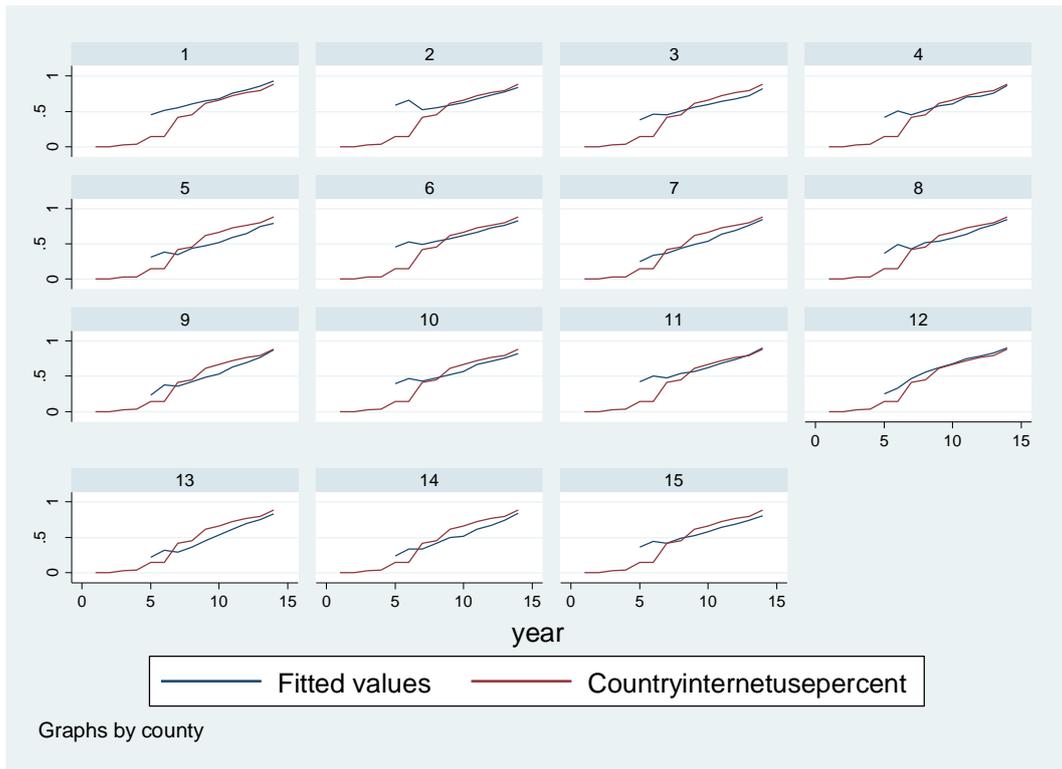
lineartimetrend4	0.0517*** (0.0161)
lineartimetrend5	0.0612*** (0.0155)
lineartimetrend6	0.0447*** (0.0163)
lineartimetrend7	0.0704*** (0.0121)
lineartimetrend8	0.0573*** (0.0195)
lineartimetrend9	0.0704*** (0.0103)
lineartimetrend10	0.0572*** (0.0202)
lineartimetrend11	0.0605*** (0.0126)
lineartimetrend12	0.0520*** (0.00920)
lineartimetrend13	0.0776*** (0.0155)
lineartimetrend14	0.0734*** (0.0140)
lineartimetrend15	0.0592*** (0.0132)
Constant	1.688 (1.174)
Year fixed effects?	No
County fixed effects?	Yes
Observations	90
Adjusted R-squared	0.87
R-squared	0.92

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12: Regression used to predict internet users.

Variable	Mean	Std. Dev.	Min	Max	Observations
predic~s overall	.6867889	.1138613	.456017	.9270701	N = 90
between		.0423634	.6276667	.7806667	n = 15
within		.1061629	.4954726	.8982361	T = 6
Intern.. overall	.6867889	.1186027	.453	.915	N = 90
between		.0423634	.6276667	.7806667	n = 15
within		.1112329	.4924556	.9236222	T = 6

Table 13: Mean value, standard deviation, minimum and maximum values for predicted internet users and internet users during 2005-2015.



Graph 8: Predicted internet users 1999-2015 and country level internet users 1992-2015. Source: Statistics Estonia & World Bank Database.

Variable	Mean	Std. Dev.	Min	Max	Observations
Countr~t overall	.6641083	.1539577	.4152	.884066	N = 120
between		0	.6641083	.6641083	n = 15
within		.1539577	.4152	.884066	T = 8
predic~s overall	.6296163	.1476907	.2913085	.915	N = 120
between		.0472883	.5670587	.7294937	n = 15
within		.1403848	.3538661	.9335332	T = 8

Table 14: Mean value, standard deviation, minimum and maximum values for predicted internet users and Country internet users during 1999-2015

VARIABLES	Model with a country specific linear time trend Voter turnout	Model with country internet usage as time trend Voter turnout	Model without any time controls Voter turnout
interaction	-0.0494** (0.0242)	-0.0504** (0.0235)	-0.0457* (0.0242)
predictedinternetusers	0.0708	0.0979***	0.0995***

	(0.0475)	(0.0372)	(0.0363)
young	-0.302	-0.389	-0.386
	(0.263)	(0.272)	(0.271)
middleage	-0.426	-0.437	-0.447
	(0.444)	(0.445)	(0.445)
Pensionage (omitted)	-	-	-
Femalesshare	2.177***	2.211***	2.079***
	(0.612)	(0.646)	(0.599)
GDPpercapita	2.54e-06	3.53e-06*	3.83e-06**
	(2.18e-06)	(2.08e-06)	(1.91e-06)
Belowuppersecondary	-0.212**	-0.243**	-0.250**
	(0.101)	(0.0993)	(0.0998)
Uppersecondary	-0.116	-0.113	-0.109
	(0.103)	(0.103)	(0.101)
lineartimetrend	0.00463		
	(0.00375)		
Localelection	-0.0339***	-0.0336***	-0.0335***
	(0.00426)	(0.00425)	(0.00427)
Countryinternetusepercent		0.0143	
		(0.0248)	
Constant	-0.268	-0.237	-0.164
	(0.423)	(0.427)	(0.422)
Year fixed effects?	No	No	No
County fixed effects?	Yes	Yes	Yes
Observations	150	150	150
Adjusted R-squared	0.65	0.65	0.65
R-squared	0.71	0.70	0.70

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *

p<0.1

Table 15: Model 1 includes a linear time trend, model 2 includes the internet use on country level as a close to linear time trend and model 3 includes no time controls.

```
( 1)  _Iyear_5 = 0
( 2)  _Iyear_6 = 0
( 3)  _Iyear_7 = 0
( 4)  _Iyear_8 = 0
( 5)  _Iyear_9 = 0
( 6)  _Iyear_10 = 0
( 7)  _Iyear_11 = 0
( 8)  _Iyear_12 = 0
( 9)  _Iyear_13 = 0

F( 9, 125) = 20.69
Prob > F = 0.0000
```

Table 16: Time dummies test.