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# EFFECT OF PUBLIC DEBT ON ECONOMIC GROWTH IN THE EUROPEAN UNION

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I hereby declare that I have compiled the thesis independently
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have been properly referenced and the same paper
has not been previously presented for grading.

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# ABSTRACT

This master thesis analyses public debt effect on economic growth in the European Union. Public debt levels have grown significantly around the world and European Union has not been an exception. Problems with public debt came evident first time in EU during financial crises and its aftermath. Meanwhile recent years have added more fuel to the fire.

The aim of this paper is to ascertain how debt levels of current European Union member are affecting their GDP growth rate and at what levels debt starts to have negative effect on the economy. In this thesis author searches answers for three questions. First research question is does debt have a negative effect on the economic growth? Second, at what level debt does the effect turn negative and third, are there different debt tolerance levels between different country clusters based on their institutional quality?

Data used for analyses covers period of 1996-2021 and baseline estimation is done with within estimator. Before running the estimation, countries are clustered into 2 groups and estimation is run with each subgroup and with full sample.

It can be concluded that probably debt has inverted U-shape relationship with GDP growth rate. Meanwhile there might different debt tolerance levels among subgroups, but evidence was not very clear. Threshold level for full sample was around 94% and subgroup with lower institutional quality had threshold level around 19%. Subgroup with higher institutional quality had threshold level around 109%, but results were not robust.

Keywords: public debt, GDP growth rate, European Union, within estimator, K-means, clustering, threshold levels

# INTRODUCTION

Debt is a double-edge sword. Used in moderation, it can improve wellbeing, but using it recklessly, it can lead to disaster. Careless use of debt causes individuals and firms to go bankrupt and financial ruin, while for country it leads to inability to deliver essential services and goods to its citizens.

Reinhart et al. (2003) claimed that after debt reached certain levels, effects of financial crises can be more severe and chances for such unfortunate events are more likely. History has shown that different countries face debt related crises at different levels of debt. The reason could be because of different historical, economic, political and institutional background. For example, war debts are considered to be less challenging than a huge level of debt build up during peacetime (Reinhart & Rogoff, 2010).

Public debt levels grew significantly over many decades among numerous countries worldwide. Such build ups of debt were generally characterized by expanding government expenditures. By the end of year 1990 multiple advanced countries public debt levels reached to 79% for larger governments (government expenditure-to-GDP is larger than 50%), 60% for medium sized governments (government expenditure-to-GDP is between 40%- 50%) and 53% for small governments (Tanzi & Schuknecht, 1997).

During the beginning of 1990's countries which belonged to European Union agreed to sign Maastricht treaty in order keep EU area financially stable. With afore mentioned treaty, members of newly formed union agreed to give up control of their monetary policy and exchange rate. Founding parties defined creation of euro area with two important fiscal agreements. It was agreed that each country should have debt-to-GDP ratio at 60% level (European Central Bank, 2021). Second rule was budget deficit which should not be more than 3% of GDP. Both rules were agreed to avoid excessive levels of debt which could harm European Monetary Union.

Rules set with Maastricht Treaty in 1992 were later redefined and improved with Stability and Growth Pact (Castro, 2011; European Central Bank, 2021). With Stability and Growth pack even the fines were created and they were up to 0.2 % of GDP, but unfortunately these have never applied in real situations (Bilbiie et al., 2021).

Last couple of years Covid -19 related crises and current geopolitical events add even more fuel to the fire. Nowadays many countries have long passed 100% government debt levels while some of them have managed to maintain GDP growth while others are stagnant. Meanwhile some countries in European Union have not even come close 60% level which is pointed out in Maastricht Treaty. Such situation raise question whether and at what level debt has negative effect? Also does different countries have different debt tolerance levels? Finding the answers to such questions helps countries to rethink their course and make adjustments when required.

The topic of public debt came strongly into picture after financial crisis and after that numerous empirical research has been conducted. Multiple papers have focused on finding evidence how debt affects economic growth, and at which point or level it has negative effect. Empirical studies have used data from both the Eurozone and globally. Current results vary slightly as number at which level debt starts to have negative effect varies.

The aim of this paper is to ascertain how debt levels of current European Union member are affecting their GDP growth rate and at what levels debt starts to have negative effect on the economy. The empirical analysis of this paper follows closely the work of Checherita-Westphal et al. (2012). The baseline model for regression analyses is derived from previously mentioned paper, but in order to understand how debt affects different economies, clustering methods are implemented. Using clustering technique, the countries are divided into different subgroups according to their institutional quality before doing the regression analysis. Data for institutional quality is obtained from World Bank. After results are derived from the baseline model author also calculates debt turning points for each group of countries.

Questions, which this paper tries to find answers to are:

1) Does debt have a negative effect on the economic growth?
2) At what level debt does the effect turn negative?

3) Are there different debt tolerance levels between different country clusters based on their institutional quality?

Taking into consideration that there are many empirical papers that indicate that debt indeed can have a negative effect the economic growth after the debt stock reaches certain levels, then author expects results of such nature. Meanwhile novelty of this paper is clustering. Aim of using clustering techniques is to group countries differently than it has been done in many other empirical papers with same topic. In this thesis the author uses world governance indicators which represent institutional quality, to group countries.

Another originality is dataset, which runs from 1996 to 2021 and uses all current member states of European Union. It covers multiple periods of recent crises. Although the periods in other papers with similar topic are generally using panel datasets with longer periods, but author is not aware of any papers using all current European Union member countries. Generally, it is either countries from all over the world or advanced countries in European Union with long periods of data. In some cases, empirical papers have included only few less advanced European Union members.

Author expects that countries with higher institutional quality have higher debt tolerance levels than countries with lower quality. First part of the paper includes theoretical and empirical literature overview, second part describes data and methodology, and third part is about results of empirical analyses.

In this master thesis author used R programming language and Stata for analyses. Zotero program was used for all references.

# 1. LITERATURE ABOUT PUBLIC DEBT AND ECONOMIC GROWTH

The first part of this master thesis gives overview of theoretical studies discussing public debt and economic growth. Then results of multiple empirical papers are discussed. Different findings of threshold levels and relationship between public debt and economic growth are brought up. Also channels through which public debt has an effect is discussed.

## 1.1. Theoretical literature

Public expenditures need to be financed either by taxes or by debt. Both sources can be used to finance some large projects and programs with high importance and benefits. In similar fashion government could use these tools to boost economy during downturns, but borrowing can be a double-edged sword as raising debt carelessly could potentially lead to problems in the future instead of prosperity (Hakura, 2020).

For example, one of the reasons why governments should be motivated towards sustainable debt levels is during extreme situations (war for example), government is mostly seen as last hope of overcoming adversaries. Due to this reason it is important for the government to keep a capability to injecting required finances into economy during such events (Cecchetti et al., 2011).

Many theories and research papers have been solely focused on government debt and many works have been created during the times of increased public debt. The most obvious place to start discussing public borrowing is Keynesian viewpoint of debt. Keynesians argue that one way how to handle recessions and downturns, governments should turn their eye to stimulating its economic activity with expansive fiscal policy. The options for boosting economy again could either be tax reduction, which requires keeping public expenses at the same or similar level (Hemming et al., 2002).

Another option is to increase government spending and finance its expenses with debt. Both these tools improve economic output, but the latter option is more preferred due to the multiplier effect. Multiplier effect states that deficit financing has stronger effect on total demand than increasing aggregate demand with tax cuts as multiplier is larger than one and GDP growth is

larger than increase in costs (Hemming et al., 2002; Ono, 2011). So it could be said that as debt can have positive effect on output, especially during the times of crises as expansive fiscal policy, it has become one of the tools in governments arsenal during difficult times (Hall, 2009).

Critics of Keynesian approach claim that public debt can be considered as sort of taxing, because debt reduces capital stock and therefore future economic growth. At the same time nature of the debt, whether foreign or domestic, did not matter (Wagner, 2014).

Similarly, Barro (1974) points out in the research that government debt as form of bonds is not viewed as wealth by the population. The reason is Ricardian equivalence, which state that consumers could expect that due to debt, taxes in the future are increased to pay off the debt. It does not lead to increased consumption but rather increase in savings. So, change in public debt causes equal change in private savings and therefore it has no effect on the economy. In similar fashion, Barro (1989) empirical finding mainly give support to viewpoint that interest rates, consumption, saving and current account balance having no effect on budget deficits while Keynesian view was opposite.

As Ricardian equivalence hypothesis is brought into a story, the hypothesis has six assumptions. First, capital markets should be perfect. Second, the population of taxpayers should grow at constant rate. Third, the time horizon should be endless as each member sees its descendant as extension of itself. So, it pretty much means that the one could live forever. Fourth, the assumption requires rationality and, fifth, assumes that future tax burden is paid by the one who directly benefits from the debt. Finally, it is assumed that tax size is equal to everyone. Therefore the debt, which is financed from increase of taxes in the future, and due to this nature consumption cannot grow because the subjects need to save more for increased tax expenses (Barro, 1974, 1989; Saungweme & Odhiambo, 2018).

Another view of public debt effects on economic growth indicates it to be negative. It could be explained by debt overhang theory which was first introduced by Myers (1977). It is argued that public debt overhang leads to lower economic growth. Negative effect of public debt is also taken into consideration in much older works and theories where current debt is paid by future citizens in form of taxes(Diamond, 1965; Modigliani, 1961; Myers, 1977). Similar view is

concluded by (Krugman, 1988) where high debt was considered acting as tax for future output and also reducing incentive to invest.

Krugman (1988) points out that debt overhang which is a situation where country's expected repayment ability on external debt falls below the contractual value of the debt. Up to certain threshold foreign debt can promote investments, but after that debt overhang sets in (Cohen, 1993). Developing countries which had lower external public debt (but not a case for external private debt) were associated with higher economic growth (Schclarek, 2004).

Modigliani (1961) claimed that public debt could become problem for the next generations, due to lower stock of private capital. Separately from crowding-out effect, Modigliani(1961) pointed out that debt could cause an impact on long-term interest rates. He argued that government may force long-term interest rates to go up thanks to decline in private capital, which tends to increase its marginal product. Therefore, author claimed that increase in debt will not be costless for future generations although it is so for current generation. In order to justify public debt, it should be used to increase real income of future generations (Modigliani, 1961). Similarly Spencer and Yohe (1970) pointed out that increasing public debt increases borrowing costs for private enterprises as less resource is available for them.

Another claimed channel is long-term interest rate through which higher debt causes higher interest rates. It can cause crowding out effect of private investment which in return reduces growth of output. Logic of it is simple: if increased debt causes higher rates, it draws money out of private investments with lower yield into public investments. This leads to increased private interest rates and thus discouraging private investments due to higher costs of borrowing. (Elmendorf & Gregory Mankiw, 1999).

It is found that connection between deficits and debt stocks. High debt stocks have deteriorating effect on already negative influence of high deficits. With theoretical model it is found that increase in productive government expenditure, which financed with rise of taxes will be growth enhancing only when public debt level (domestic) is low enough (Adam & Bevan, 2005).

Some authors have pointed out that that removal of so-called deadweight debt would raise household desire to save more (the Pigou- effect) and improve reasons for work and enterprise.

Also, it possibly allow reduction of income tax at later stage because of better budget due to lower interest payments (Meade, 1958).

Another author, which includes the effect of taxes on capital stock and makes difference of external and internal public debt, concluded that with the increase of taxes, which is needed to finance interest payments, both types of debt reduce available income and savings, therefore capital stock, of the taxpayers. Further growth of internal debt only exacerbates afore mentioned situation due to the debt substitution effect on individual portfolios (Diamond, 1965).

By some authors it is claimed that the way how debt builds up have different way of impacting economic growth. For example, Reinhart and Rogoff (2010) point out that debt accumulated during the times of war could be less problematic than accumulation of debt during peace. The reason could government spending which immediately drops after war is over while peacetime debt last longer periods.

After discussing potentially harmful nature of high levels of debt, then many studies however have found that borrowing can have non-linear effect on growth. It is concluded in quite a few papers that debt has inverted U-shape effect (Checherita-Westphal & Rother, 2012; Mencinger et al., 2014; Reinhart & Rogoff, 2010). It means that before debt to GDP reaches certain threshold level, it does not have a negative effect, instead it rather benefits the economic growth in the long run.

Aschauer (2000) provided a model where public capital has a non-linear impact on economic growth. It can be extended to cover the impact of public debt. Assuming that government debt is used at least partly to finance productive public capital. So up to certain threshold debt will have a positive effect after which it will be negative (Aschauer, 2000).

## 1.2. Empirical literature

Numerous studies about public debt and its effect on the economic growth have been conducted after financial crises. Many of the paper have looked for confirmation of debt having inverted U-shape effect on the GDP growth and through which channels debt affects it.

Reinhart and Rogoff (2010) conducted research on global scale of 44 countries covering almost two centuries of data. Their main finding was that both developed and developing countries, which have debt-to-GDP ratio over 90%, had significantly lower growth rates. For emerging countries however adverse impact of public debt already started from 60% level of debt-to-GDP.

Kumar et al. (2015) conducted a study using panel dataset of developed and developing countries over period of 1970-2007 and found that debt has negative effect on the economic growth. On average 10% increase of debt-to-GDP ratio causes a slowdown of growth rate by 0.2 percentage points per year. Impact of such slowdown was smaller (about 0.15) for developed countries. They found some evidence of nonlinear impact, but statistical significance was confirmed only for the countries with debt-to-GDP ratio above 90%. Negative effect of public debt was associated with decline in investments and with smaller growth rate of capital stock per worker.

Pattillo et al. (2004) concluded that impact of debt on the economic growth can be very different and its dependent of its level. High level of debt was found to have large negative impact and low levels of debt have generally positive effect, although the effect is mild. The authors concluded that high levels of debt affect physical capital accumulation and total factor productivity negatively. Through these channels economic growth rate declines. It was found that doubling initial level of debt reduces GDP growth rate by 1%.

Another paper using cross-sectional data of 155 countries found that debt has negative effect on economic growth in the overall sample. Also, countries with debt-to-GDP ratios above 90%, the impact of another 10% increase in debt has -0.2% effect on growth, which is very similar to Kumar et al. (2015) results. Although on the other hand, having debt ratio lower than 30%, an increase of debt by 10% increases growth rate by 0.1%. On average the debt threshold levels were at 59% level. In this paper the existence of inverted U-shape relationship was confirmed and the results were robust. They also found that higher debt levels seemed to be beneficial for growth of total factor productivity and capital stock per worker. Meanwhile it undermined both private and public investment (Afonso & Jalles, 2013).

Another study which also gives confirmation to positive effect of the debt was conducted in 2020 and it used data of Euro Zone countries between 2000-2019. It showed that public debt and economic growth are positively correlated (co-movement) for most examined countries in the

long-run period (more than two years). The results confirm classical theory of public debt, according to which the debt has increases GDP growth in short-term, while will harmful effect in a long run (Albu & Albu, 2021).

Mencinger et al. (2014) conducted a study with data of European Union member states and found that inverted non-linear effect of public debt exists. It was concluded that older members of European Union start to have negative effect at 80 to 94% levels of debt to GDP. Meanwhile newer members had much lower threshold levels. Their upper limit, after which harm to economic growth appeared, were between 53% to 54 % of GDP. Although in this paper robustness tests were not conducted (Mencinger et al., 2014).

Similar results to Reinhart and Rogoff (2010) were also found in study which analysed countries in Euro Area (included 12 countries). It was found that on average the threshold level of debt to GDP was between 90%-100% and after that growth rates started to decline in long-term. However statistical confidence levels were found to be going as low as 70% of debt to GDP suggesting that by the time of study the debt levels for many countries were already causing damage to the economy in the long-term. Negative association of annual changes debt and budget deficits (linear association) to economic growth rate were also found. Both give a way to argument that detrimental effect of debt could be lower than previously mentioned average. The authors also point towards the potential channels through which debt is affecting economic growth negatively. These were total factor productivity and sovereign nominal and real interest rates, private savings and public investments (Checherita-Westphal & Rother, 2012).

Another study, covering 18 OECD countries over the period 1980-2006, has proposed that high debt levels can be threat to economic growth. The potential threshold could be 85% of debt to GDP ratio and after that an increase of debt by 10% can cause reduction in growth by more than 0.1 percentage point (Cecchetti et al., 2011).

Study which examined 99 countries (both developed and developing) over period from 1980 – 2008 estimated average threshold to be 77% of GDP. When using subsample of developing countries average threshold level of debt-to-GDP ratio was 64%. The authors of the paper estimated potential loss in GDP growth rate. Annual percentage point losses ranged from 0 to 4.7. They concluded that short term deviation from the average threshold level was not damaging

to the economy. Rather the problematic is when debt has moved a lot over threshold level and country keeps it for long period of time (decades), then economy is likely going to suffer. (Caner et al., 2010).

Paper, which analysed specifically countries with low income in period 1970-1999, found that high levels of debt can have negative effect on the economic growth. Confirmation for nonlinear impact of debt was also found and estimated threshold level of public debt after which deteriorating effect sets in was around 50% of GDP. High levels of debt were also claimed to affect economic growth indirectly through its effect on public investment. The paper says that external debt may have an indirect effect on economic growth through debt servicing costs, rather than harming public investments directly, and its nature seems to be non-linear. When debt service cost rise compared to GDP the crowding out effect intensifies. On average every 1 % point increase in service costs results in 0.2% point reduction of public investments (Clements et al., 2003).

Paper which analysed group of Latin America countries found that there is statistically significant inverted U-shape relationship between public debt and economic growth. Estimated turning was between 64 and 71%. The sample included 15 Latin American countries over period of 1960-2015. Another interesting finding was higher debt tolerance of more democratic countries (Jacobo & Jalile, 2017)

Study which investigated effect of public debt on economic growth and its influencing factors using 102 countries from 1980 to 2016 confirmed nonlinear relationship between public debt and GDP growth. Such conclusions were drawn for developing, emerging, and developed countries. The authors found that improvements of current account balance of developed countries could improve their debt threshold level, while increase of gross savings improves threshold for both emerging and developing countries. At the same time trade openness lowers threshold level of emerging and developing countries while it contributes in rise of threshold for developed countries (Liu & Lyu, 2021).

Another paper, which specifically studied public debt effect on the Israeli economic growth rate in a period of 1983 – 2013, concluded debt threshold level for the country was 130% of public debt of GDP. As coefficient of debt-to-GDP ratio was positive and square of the same variable

was negative, then it indicated inverted U-shape relationship. Such result is mostly in line with many other empirical papers, but the estimated threshold level is much higher (Shahor, 2018).

One more paper which focused on one country only used data of Spain which spanned from 1851 to 2013. Authors of this paper found that around 10% increase of public debt was associated with 0.7 percentage point lower GDP growth rate. In this case the authors did not find any clear threshold levels after which debt starts to have negative relationship (Esteve & Tamarit, 2018).

Some studies on the other hand have found no clear evidence of a causal relationship between debt and economic growth and even so for highly indebted countries. For example Panizza et al. (2014) investigated 18 OECD countries and data ranged from 1980-2006. They concluded that there is no clear evidence of debt having non-linear relationship among advanced countries used in their study. The effect of debt on the GDP growth depends on its structure and how it was accumulated. However, the author pointed out that despite the fact they were not able to confirm negative effect on the growth, it does not mean that country can withstand any level of public debt. Eventually negative influence of very high debt-to-GDP ratio will come up in one way or another.

Another paper which did not find causal relationship between public debt and GDP growth rate used EU and OECD countries data from 1995-2013. Even when splitting countries into subgroups according to their development level, the results stayed the same. However, they found the link of interest rate transmitting negative effect to economy through public debt. Accumulation of debt raises interest rates which in turn lower demand for interest sensitive products, but which is overcome by increasing public borrowing. Authors argued that after market starts to perceive debt levels as unsustainable which causes fast raise in long term interest rates. Through this channel the public debt may start to affect economic growth negatively (Jacobs et al., 2020).

A study which examined countries in multiple periods found little evidence of a non-linear relationship between debt and GDP growth. The paper used multiple models, which created quite different outcomes. When data from period 1946 to 2009 was used, evidence of non-linear relationship was rather limited. On the other hand, using shorter timeframe the result slightly

improved. The results of the models suggested negative effects of debt at levels between 20% to 60% of GDP. Authors pointed out results being extremely sensitive of time dimension and country coverage. Also, outcomes are affected by data frequency (annual data or averages of multiple years) and number of observations in dataset. It was concluded that as their results were quite different from studies conducted before, then topic itself might be more complex than previously thought, as economic instability may be consequence of non-linear effect changing over time and due to this reason findings of many authors are dependent on used sample (Égert, 2015).

Study which focused more on time trajectory found that there is no clear threshold level of debt on medium-term period. In the short-term period the relationship between public debt and GDP growth rate was proved to exist. They found that debt-to-GDP- ratio is larger than 90% then economic growth is significantly lower. Such results are in line with findings of Reinhart et al. (2010) paper which pointed out same threshold level. They also found that countries with high levels of debt level were associated with much more volatile growth rate than nations with low debt and trajectory of the debt influencing factor of economic growth. If the country had high but declining debt, then they grew just as fast as the countries with low levels (Pescatori et al., 2014).

In the afore-mentioned paper longer periods were also analysed. High levels of debt seemed to still result in slower growth rate, but clear threshold level was not found. Interesting finding was that trajectory debt is important in influencing the growth. Countries with high but declining levels of debt grew historically as quickly as their peers (Pescatori et al., 2014)

Research, which examined Asian countries in period 1980 - 2012, looked for both short and long-term effects of public debt on GDP growth. Based on results authors concluded that common belief of harmful debt levels of 90% or more may not apply to Asian countries. During the time of the study Asian countries had relatively modest debt levels, although some negative effect was still found for both short -term and long-term timeframe. Interestingly, the short-term decline in public debt did not increase output at all but according to authors it likely will do so in long-run (Asteriou et al., 2021).

Another paper, which investigated both linear and nonlinear relationships between debt and economic growth for developing and industrial (countries can be considered as developed

nations) countries. The results showed that there seems to be negative relationship between external public debt and GDP growth rate for developing countries. They managed to specifically analyse effect of external public debt and private debt. Findings pointed out that public external debt has negative relationship with GDP growth, while private external debt did not, and evidence of nonlinear relationship was rather limited. It led to the conclusion that public debt is probably one of the channels affecting economic growth. Similar analyses conducted using industrial countries lacked evidence of both linear and non-liner relationship between debt and GDP growth rate. Although the author points out channel through which public debt accumulation affects economic output was concluded to be mainly growth of capital accumulation. On the other hand, total factor productivity, which is suggested in some other papers, gave limited results. On the other hand, private saving seemed not to be affected and lack of robust results were in interest payments and debt service costs.(Schclarek, 2004).

One paper which used meta-regression methods to 816 estimates from 47 major paper in subject concluded that about 10 percent increase of debt-to-GDP ratio led to 0.14 percentage decrease of growth rate. Meanwhile authors of the afore mentioned paper pointed that despite wide acceptance of negative effect of public debt and certain thresholds, the there is some evidence of so-called publication bias. It means that there is some favouring of papers which report negative effect of public debt after certain level of threshold. The analyses pointed out that literature reports very little zero or positive growth effects of public debt levels on growth than it should. In the same paper it was indicated that there is little evidence of certain threshold and all previous results of existence of threshold levels are varying a lot and are highly sensitive to underlying data and econometric model choices. Reasons could be nonstationary of underlying data, outliers and endogeneity (Heimberger, 2022).

Taking all presented empirical papers into account the results vary a lot. Those papers that confirm for example inverted U-shape relationship between public debt and GDP growth give scattered threshold levels. The average threshold levels of debt-to-GDP ratio for more advanced countries seemed mostly vary in range of 70%- 100%. Same variability was also among the results of less advanced countries. At some cases threshold level was as low as 20% (Égert, 2015). Such variability leads to conclusion that evidence of existence of certain threshold level is rather scarce. Such conclusions were also pointed out by Heimberger (2022).

There are also some papers which did not find any confirmation for existence of inverted U-shape connection between public debt and economic growth rate. Although there are more papers pointing towards the existence of inverted U-shape relationship.

# 2. Data and methodology

This part of master thesis focuses on dataset and methodology used for estimations. First it discusses different ways of measuring effect of public debt on economic growth, which are obtained from previous empirical papers then it continues with discussion of dataset. It is important to discuss econometric methods used in previous literature to explain and give an understanding of possible options of methodology in this paper. Most of the older papers use similar methods while newer papers try to introduce more novel techniques. Also, as this master thesis includes clustering then also clustering techniques and its results are discussed. Similarly empirical model is part of this chapter.

## 2.1 Methods for measuring the effects of debt on economic growth

Research paper by Clements et al. (2003) estimated model using both fixed effects and system general method of moments (GMM). Study uses data on 55 low-income countries in period of 1970 to 1999. The advantage of fixed effects is consistency in country specific effects which are correlating with explanatory variables in the model. Although as they added lagged income variable there is potential for results to be affected by Nickel bias. They address this problem with system GMM, which can address endogeneity of variables. Both methods gave similar results and finding concluded some support for debt overhang hypothesis.

Another study conducted by Kumar et al (2015) estimation strategy was to use variables which are directly associated with growth and other variables importance is evaluated before adding them into a model. The core set of economic variables have additional debt variable which is at its initial level so to avoid reverse causality problem. Although the authors concluded that reverse causality may not be an issue because lower debt is more likely the one that leads to high debt than the other way around. They used multiple models: pooled OLS, between estimators, fixed effects panel regression and system GMM. It is noted that each model has its own trade-offs.

Study of euro area countries by Checherita-Westphal et al. (2012) used panel fixed effects corrected for heteroskedasticity and autocorrelation up to order 2 as the baseline estimation. Due to strong potential of endogeneity of debt variable they use various instrumental variable

estimation, GMM and 2SLS and compare these with the baseline estimation. Other robustness tests included removing some of the countries (outliers) and some of the years from dataset. They also implemented annual lag of 1 year, lag of 5 years and lag of 5 years with cumulative overlap. Authors claimed that it is important to keep in mind that negative impact of public debt on growth could be significantly stronger among countries which are high in private debts. To measure this, they used total domestic credit to the private sector variable.

The paper by Mencinger et al. (2014) analysed 25 European Union member states used fixed effects and instrument variable approach. Specifically two-stage GMM estimator with instrument variables as it followed closely Checherita-Westphal et al. (2012) work. The authors divided countries in to two groups whether they were new or old member states.

Another paper by Liu et al. (2021) used fixed effects and instrumental variables with panel data. Author classified countries into three groups: developing, emerging, and developed countries. The reason was that most studies have focused on developed countries only and therefore there were little results among other country groups. They run estimation on full sample and subgroups separately.

Study by Jacobs et al. (2020), which was conducted on EU and OECD countries used panel data from period 1995-2013. Estimator used in this study was VAR model and individual heterogeneity was controlled with fixed effects. In order to avoid biased estimates due to lagged dependent variables they used forward-mean differencing in order to eliminate fixed effects, which were estimated with SGMM model. Later the time fixed effects were added to VAR model as exogenous variable.

Another study, conducted by Cecchetti et al. (2011) used within estimator on panel data and at later stage they added various non measures of non-financial debts to see whether they have any impact. Model was derived from Solow growth model. In order to minimize endogeneity bias five-year forward average growth rates were used.

In recent years paper by Albu et al. (2021) have used novel models for analysing debt effect on growth rates. In one research a Wavelet approach was used. Authors claimed that this method provides new insight to the topic, because it allows to study relations and synchronized

movements between economic variables at different timeframes. Wavelet transform allows to inspect variables in both time and frequency, which has an advantage over more traditional non-linear methods.

In multiple papers lagged debt variables were used. Égert (2015) explains that in this way correlation of public debt and growth can be avoided as any change in growth in the growth of real GDP will have an effect on debt-to-GDP ratio. They use quite simple empirical model with only debt variable (linear model) in it and use within estimator with country fixed effects. After they test thresholds pointed out in Reinhart et al. (2010) paper. Using such multiple regimes technique has its shortcomings in form of regimes and thresholds being arbitrary.

Some papers have handled the subject with slightly different approach. The paper by Asteriou et al. (2021) which used data of 14 countries in Asia over period of 33 years ran Mean Group, Pooled Mean Group and dynamic two-way fixed effect estimators with given dataset. They specifically avoided using GMM estimator, which in many cases has been used in previous empirical literature. They pointed that the number of countries was smaller (N = 14) than the time frame of the dataset (T = 33). In such case GMM estimator is not a best option.

Another paper, Pereima et al. (2016), used a slightly different approach and compared several estimation methods. The methods were between estimator, fixed effects combined with threshold, two stage least squares and GMM. The novelty in this paper was clustering countries differently using hierarchical clustering methods with institutional quality data. They ran analyses with full sample and with clustered subgroups.

It can be concluded that most of the papers include fixed effect estimator in their analyses. Multiple papers compare results of fixed effects with GMM estimator but not all. A few papers have tried to approach the subject differently and introduced new ways of analysing the topic of public debt affecting economic growth.

## 2.2 Data

This master thesis uses data, which is mainly originated from Eurostat, World Bank and AMECO databases. Sample dataset includes 27 countries ranging from 1996 to 2021, which all currently

belong to European Union. The dataset contains annual data. All data for estimating debt effect on economic growth was obtained from Eurostat and AMECO databases (in few cases World Bank database was also used). Combination of both databases was used, because multiple cases some of the years were missing from one of the databases.

The economic data (also see Appendix 1 for the names of variables used in estimations) used in the analyses included GDP growth rate, GDP per capita, Government debt as a percentage of GDP, Fixed capital formation, population growth rate, government revenues as percentage of GDP, government deficit or surplus as a percentage of GDP, exports and import of goods and services (based on these indicators openness indicator was calculated by author), the long-term interest rate, and the real effective exchange rate.

As some of the years were missing and were hard to obtain, so these missing values were either interpolated or extrapolated. Most of the missing values, were among former communist countries with few exceptions like Germany and Italy. Missing years ranged from 1990s to the beginning of the 2000s. Most of the time missing values were among exports and long-term interest rate variables. Rest of the variables had only a few years missing if any.

The author obtained World Governance Indicators (WGI) dataset from World Bank database. This WGI data was used for clustering of the 27 EU countries, and data included period from 1996 to 2020. Data for the years 1997, 1999 and 2001 was missing. The WGI dataset included six variables: voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law and control of corruption. Variable values ranged from -2.5 to 2.5 (lowest score indicates lowest quality of variable and vice versa).

Author used mostly R and its libraries for data related tasks, clustering and for estimation. In few cases Stata and Excel were also used for estimations and calculations.

Before continuing with clustering, it is useful to look at two most important economic variables in this thesis, which are GDP growth rate and public debt to GDP ratio (variables used for clustering are discussed in 2.3). From table 1 it can be seen that average of the debt-to-GDP ratio for most of the countries is less than 100%. Highest average debt-to-GDP ratio is among Greece and Italy. Also, Belgium has quite high average public debt. In meantime when looking at year

2021 public debt levels it can be seen that most of the countries debt levels have grown over their average, although their growth rate is also higher than historical average, but historical average also includes extreme years like financial crises. Greece has had the highest debt growth while Bulgaria has managed to lower its debt level from historical average (see also graphs at the Appendix 2)

Table 1. Debt levels and GDP growth in 2021 and their averages during 1996-2021

| Country | Average of public debt-to-GDP Ratio, % of GDP | Average of GDP growth rate, % | Public debt-to-GDP in 2021, % of GDP | GDP growth in 2021, % |
|---|---|---|---|---|
| Austria | 0.735 | 0.016 | 0.828 | 0.046 |
| Belgium | 1.050 | 0.017 | 1.082 | 0.062 |
| Bulgaria | 0.355 | 0.022 | 0.251 | 0.042 |
| Cyprus | 0.739 | 0.027 | 1.036 | 0.055 |
| Czechia | 0.300 | 0.024 | 0.419 | 0.035 |
| Germany | 0.669 | 0.013 | 0.693 | 0.026 |
| Denmark | 0.414 | 0.016 | 0.367 | 0.049 |
| Estonia | 0.079 | 0.042 | 0.181 | 0.08 |
| Greece | 1.390 | 0.008 | 1.933 | 0.083 |
| Spain | 0.727 | 0.018 | 1.184 | 0.051 |
| Finland | 0.500 | 0.021 | 0.658 | 0.03 |
| France | 0.795 | 0.015 | 1.129 | 0.068 |
| Croatia | 0.538 | 0.022 | 0.798 | 0.102 |
| Hungary | 0.685 | 0.025 | 0.768 | 0.071 |
| Ireland | 0.600 | 0.060 | 0.560 | 0.136 |
| Italy | 1.212 | 0.005 | 1.508 | 0.066 |
| Lithuania | 0.286 | 0.042 | 0.443 | 0.05 |
| Luxembourg | 0.149 | 0.033 | 0.244 | 0.069 |
| Latvia | 0.267 | 0.037 | 0.448 | 0.045 |
| Malta | 0.590 | 0.046 | 0.570 | 0.103 |
| Netherlands | 0.566 | 0.019 | 0.521 | 0.049 |
| Poland | 0.475 | 0.039 | 0.538 | 0.059 |
| Portugal | 0.929 | 0.012 | 1.274 | 0.049 |
| Romania | 0.272 | 0.031 | 0.488 | 0.059 |
| Sweden | 0.460 | 0.024 | 0.367 | 0.051 |
| Slovenia | 0.450 | 0.027 | 0.747 | 0.082 |
| Slovakia | 0.446 | 0.035 | 0.631 | 0.03 |

Source: Eurostat, AMECO, World Bank, author's own calculation

Figure 1 shows the average GDP growth rate and the debt-to-GDP ratio. It follows from the figure that larger the public debt is generally associated with lower growth rate. Such conclusion

was also drawn by Reinhart et al. (2010). Although from this graph it is hard to see any evidence of debt having inverted U-shape relationship with economic growth. It rather shows that lower debt means higher growth and vice versa but including more countries into a dataset may give totally different understanding as the current data has only 27 countries in it.

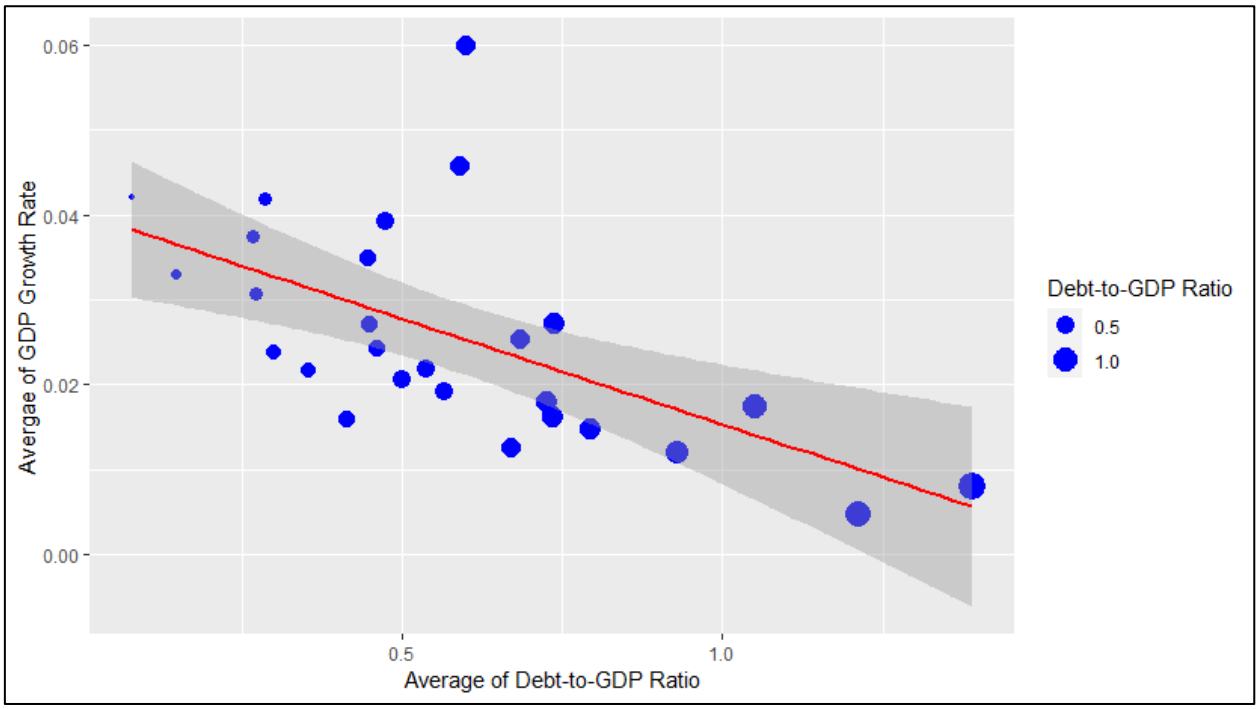


Figure 1. Debt to gdp ratio and GDP growth rate with regression line
Source: Eurostat, AMECO, World Bank, author's figure

## 2.3 Clustering

Some empirical papers authors have grouped countries according to their development level (for example see Afonso et al. (2013) or in case of the European Union as old members and new members (for example see Mencinger et al., 2014). As these classifying methods are one of the easiest and most straightforward ways of grouping countries, then they are also most widely used in empirical literature. In this paper author has decided to group the 27 EU countries into groups based on governance indicators which represent institutional quality.

So far public debt and GDP growth related empirical papers have given mixed results about the level at which negative effects kick in and it is also not clear why some countries withstand higher debt levels while other do not. Therefore, author decided to group countries according to their institutional quality.

In one paper it was concluded that institutional quality affect economic output in positive way (Valeriani & Peluso, 2011). Similar results were obtained in another study which concluded that institutional quality may be more important than so called traditional variables like investment in physical capital or population growth (Fabro & Aixalá, 2009). As there is some evidence that the quality of institutions may affect economic performance, the quality of institutions may also help to withstand the adverse effects from public debt. When clustering the countries according to their institutional quality, the effect of debt on economic growth rate might be different among newly formed groups. Also, it is expected that threshold levels among subgroups will vary.

Only known paper where cluster analyses was introduced and which analysed similar topic was conducted by Pereima et al. (2015). The countries were clustered into subgroups using Wards hierarchical clustering method. They used 154 countries and that number of countries allowed them to create 5 groups with reasonable size. According to authors clustering allowed creating more homogenous groups on which to perform estimations and they argued that such quality of institutions influences outcome or results of public expenditure and public debt.

As discussed in Section 2.2, in order to cluster the countries into groups author uses governance indicators which were available from the World Bank database. World Bank indicators scores varied from -2.5 to 2.5, and it included data from 1996 to 2020. As some years were missing another dataset was also created were missing years were interpolated. It was used to compare original dataset with interpolated dataset. See table at Appendix 1 where each variable with their meaning is given.

Before continuing with clustering, it is useful to consider the variables of each country (see Appendix 2). Looking at averages of each variable of each country, there are some differences among countries. There are very few countries with negative values of the governance indicators. The only countries with negative variables are Bulgaria and Romania. Both have low score for Control for Corruption. Bulgaria also has low score for Rule of Law while Government effectiveness of Romania is in negative territory. The rest of the countries have all variables in positive territory. Data shows that most of the advanced countries have relatively high scores compared others. Generally, absence of violence and terrorism shows the lowest scores while regulatory quality shows the highest. Control for corruption has highest variability and generally

speaking, more advanced nations show higher score (with few exceptions). Voice and accountability vary the least.

Table 2. Average scores of all countries

| Variable | Average scores | Standard deviation | Max. | Min. |
|---|---|---|---|---|
| Control of Corruption | 1.0042 | 0.7889 | 2.3324 | -0.2565 |
| Government Effectiveness | 1.1109 | 0.5987 | 2.0776 | -0.1901 |
| Political Stability and Absence of Violence/Terrorism | 0.7969 | 0.3626 | 1.4046 | 0.0849 |
| Regulatory Quality | 1.1631 | 0.4283 | 1.8262 | 0.3946 |
| Rule of Law | 1.0922 | 0.6102 | 1.9965 | -0.1071 |
| Voice and Accountability | 1.1063 | 0.3376 | 1.5700 | 0.4418 |

Source: Worldwide Governance Indicators, Author's own calculations

Author of this master thesis is using K-means clustering method, because it is one of the most widely used unsupervised learning algorithms so far. According to Jain (2010) K-means clustering ease of implementation, simplicity, efficiency and empirical success is the reason for its popularity.

K-means algorithm is partitional clustering method which is generally used with Euclidean distance. The main idea of K-means clustering is finding a centroid for each cluster and each datapoint should have minimal distance from centroid. Meanwhile each centroid of each cluster should be as far as possible from each other. In this way newly formed groups are most homogenous (Jain, 2010)

First the algorithm starts with finding centroids, then algorithm assign datapoint around each centroid and the process is repeated again until code finds the most optimal place for centroid (until it does not change its position anymore). More difficult part is defining the number of clusters the algorithm should produce as these should be input from the user. There are a multiple ways how to validate suitable number of clusters like Bayesian information criterion, Akaike information criterion, Dunn's index, silhouette method, elbow method are a few ways how to validate (Jain, 2010; Kodinariya & Makwana, 2013; Sinaga & Yang, 2020).

In order to perform K-means clustering, one should know how many groups the dataset is going to have. In order to find this out the author used silhouette and elbow graphs to confirm number

of clusters. Also, the R library NbClust offers numerous ways for confirming the number of cluster (methods like Dunn index), so in total 6 methods were used to find suitable number of groups. Possible number of clusters ranged from 2 to 26. Most of the times however 2 or 3 clusters were suggested. So, selection of cluster sizes for K-means clustering was either 2 or 3.

Clustering was tested with both 2 and 3 subgroups, but in case of using 3 clusters the third group contained very few countries (4 countries). Such a small subgroup may make it more difficult to estimate debt effect on economic growth during the next stage of analysis then author continued with two groups. The author also used Wards hierarchical clustering for confirming whether the use of 2 clusters seemed reasonable or not. Clustering was performed with both Euclidean and Manhattan distance, but both gave the same results and therefore author used result where Euclidean distance was used.

Running the K-means algorithm, it grouped the 27 countries into two separate groups based on their characteristics. The result was compared with hierarchical clustering, which produced similar result.

In conclusion author continued with results of 2 clusters because using 3 clusters produced very small groups among some clusters. At later stage it can affect the results due to small sample size. Also, Euclidean distance based results are used as there was no difference between the results when Manhattan and Euclidean distances are used.

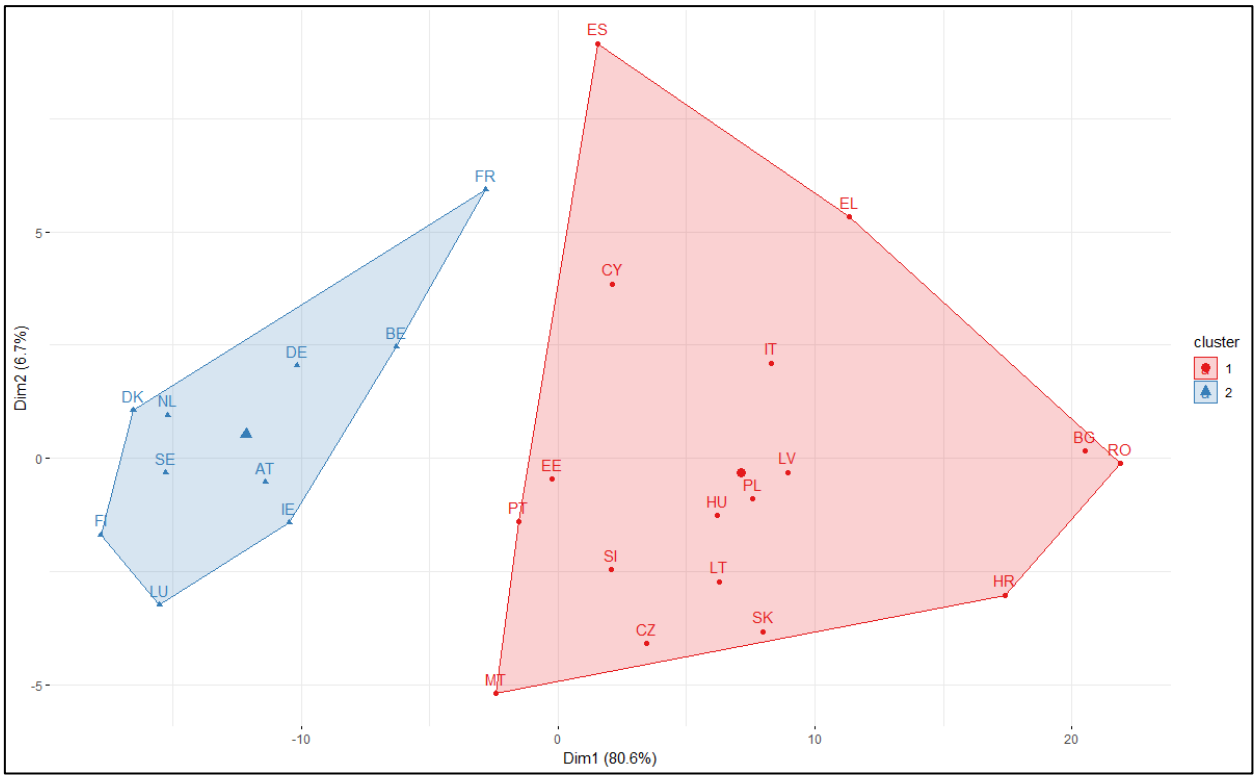


Figure 2. Results of K-means clustering
Source: World Governance Indicators, author's own calculations

Blue group (Group no 2) showed lower scoring for Voice and accountability (VoiceAccount), Political Stability and Absence of Violence/Terrorism (PolStabViol), Government effectiveness (GovEffect), Regulatory Quality (RegQual), Rule of law (RuleLaw) and Control of corruption (ContrCorrupt) throughout the years, while second group had higher scoring. Scoring ranged from about 0.674 to 1.994. In a meantime red group (group no. 1) had lower scoring, which ranged from about 0.358 to about 1.016. Conclusion of similar results were possible when looking at the graph (see Appendix 2).

As not all the countries were so easily distinguishable, and some landed in the middle then distances of red group (group no. 1) from the centroid tends to be larger than among blue group (group 2). It can be concluded that blue group is more homogenous than the red group. When testing with three groups then the red group become more homogenous but as previously mentioned the third group had too small number of countries in it and probably makes further analysis more difficult due to very small sample size. Clustering algorithm would have produced more homogenous results when larger number of countries would have been in the dataset. For example, Pereima et al. (2016) had dataset of 154 countries and they managed to create 5 groups with reasonable size.

The results of clustering are somewhat expected as nearly all developed countries are in blue group (group no. 2), which has higher scoring, while all new European Union members are in red group (group no. 1). Also so-called PIGS countries (except Ireland) are in first group (red), but clustering rather follows the logic of looking for similarities than anything else.

Table 3 Means of clustering result

| | Group | Means | Group | Means |
|---|---|---|---|---|
| VoiceAccount | Red | 0.905 | Blue | 1.453 |
| PolStabViol | Red | 0.647 | Blue | 1.085 |
| GovEffect | Red | 0.718 | Blue | 1.764 |
| RegQual | Red | 0.866 | Blue | 1.595 |
| RuleLaw | Red | 0.696 | Blue | 1.729 |
| ContrCorrupt | Red | 0.493 | Blue | 1.887 |

Source: World Governance Indicators, Author's own calculations

## 2.3 Empirical model

After clustering the author continues with empirical model following closely Checherita et al. (2012). The aim is to investigate whether there exists a nonlinear impact of government debt on the rate of economic growth and whether the effects differ among subgroups. According to Checherita et. al. (2012) linear form does not produce significant results, therefore using quadratic equation is necessary. Some previous works point out that estimations carry a risk of heterogeneity and endogeneity problems which in turn give biased result using pooled OLS estimator (Kumar & Woo, 2015; Mencinger et al., 2014; Pattillo et al., 2004). In order to capture country specific unobserved effects, the solution is using fixed effects estimator. Problem of endogeneity is corrected by introducing lagged explanatory variables into a model. In this case the author uses 1 year lag.

On the left-hand side, the model has the GDP growth rate ($Gdp2015LogGrw_t$). On the right hand side of the model there is the initial level of GDP per capita in natural logarithmic form ($\log(Gdp2015Pc_{t-1})$), the fixed capital formation as a percentage of GDP ($FixCapForm_{t-1}$) which represents investments, government debt as percentage of GDP ($GovDebtGdp_{t-1}$), and the

population growth rate ($PopGrw_{t-1}$). As this is quadratic model, the debt variable in power of two ($GovDebtGdp^2_{t-1}$) is also added (see list of variables at Appendix 1).

The model includes control variables like government revenue ($GovRevGdp_{t-1}$) and budget ($GovBudget_{t-1}$) in order to capture the effects of fiscal policy on the economic growth. Both variables are as a percentage of GDP. Variables indicating countries openness ($Open2015Gdp_{t-1}$), which is given as percentage of GDP, and real effective exchange rate ($Reer2015_{t-1}$) are used in order to expand the equation further from closed economy model. Also, long-term real interest rate ($LInterest_{t-1}$) is introduced, which should help capturing the effects of monetary policy. The model also contains country ($\mu_i$) and time ($\nu_t$) fixed effects. The variable $\varepsilon_{it}$ marks the error term in the equation (see list of variables at Appendix 1).

Main estimation equation is:

$$Gdp2015LogGrw_{it} = \alpha + \beta log(Gdp2015Pc)_{it-1} + \gamma_1 GovDebtGdp^2_{it-1} + \gamma_2 GovDebtGdp_{it-1} + \delta FixCapForm_{it-1} + \varphi PopGrw_{it-1} + \eta GovRevGdp_{it-1} + \theta GovBudget_{it-1} + \omega Open2015Gdp_{it-1} + \kappa LInterest_{it-1} + \lambda Reer2015_{it-1} + \mu_i + \nu_t + \varepsilon_{it}$$

Before running the estimations, Levin-Lin-chu unit root test was conducted (see Appendix 3). Unit root test was run on each variable separately and all variables except LInterest were stationary. LInterest variable was differentiated to order 1.

In this paper the main model is estimated with the within estimator using R programming language. As data was clustered, within estimator is run with all subgroups and full dataset separately. Same estimator is used for robustness and sensitivity tests. For further testing the author introduced lagged dependent variables into analyses. Tests are conducted in similar manner as baseline estimation, meaning that the model is estimated for all subgroups and the full sample separately and mostly author used within estimator.

Although in numerous empirical studies Nickell bias is addressed with GMM estimator, but this estimator has numerous problems like becoming consistent with large number of cross-sections. It should have lower number observations (N>T). Another difficulty is finding suitable instruments (Staehr & Urke, 2022). Also, as number of time periods is becoming larger the Nickell bias declines. Such results were shown by Judson et al. (1999) and Bun et al. (2001),

who ran multiple Monte Carlo simulations and concluded that Nickel bias is modest when there is around 20 or more time periods. Due to afore mentioned reasons this master thesis uses within estimator for baseline results and for robustness/sensitivity tests. When introducing lagged dependant variable into robustness test, then one test is using bias-corrected LSDV dynamic panel estimator, which was first described in Bruno (2005).

# 3. Results and conclusions

This part of master thesis discusses result of empirical model. It starts with discussion of results of each subgroup. Then results of full sample is discussed after which threshold levels of public debt are calculated. Results are also compared with previous empirical literature.

## 3.1 Results in each group

After running the estimations on both groups (results of estimations are presented in table 4), it is possible to conclude that significance of the results varies somewhat between subgroups. For the first group (red group), which has weaker institutional quality, debt variables did not produce any significant results. Signs of each variables estimated coefficients were in line with theory, which means that at first debt has positive effect then after certain threshold it turn negative.

Meanwhile debt variables of second subgroup (blue group) produced significant results among both debt variables. Sign of each estimated coefficients were similar to red group.

Table 4. Model output with subgroups and whole sample

| **Result of Whole Sample and Subgroups** | | | |
|---|---|---|---|
| | *Dependent variable: Gdp2015LogGrw* | | |
| | Group 1 (red group) | Group 2(blue group) | Whole Sample |
| lag(log(Gdp2015Pc), 1) | -0.072*** | -0.070** | -0.061*** |
| | (0.021) | (0.030) | (0.015) |
| lag(I(GovDebtGdp2), 1) | -0.018 | -0.093* | -0.026** |
| | (0.014) | (0.051) | (0.012) |
| lag(GovDebtGdp, 1) | 0.007 | 0.203*** | 0.049** |
| | (0.029) | (0.074) | (0.024) |
| lag(FixCapForm, 1) | -0.002 | 0.066 | 0.042 |
| | (0.078) | (0.088) | (0.056) |
| lag(PopGrw, 1) | -0.867* | 0.486 | -0.562 |
| | (0.458) | (0.569) | (0.349) |
| lag(GovRevGdp, 1) | -0.065 | -0.098 | -0.095 |
| | (0.111) | (0.153) | (0.083) |
| lag(GovBudget, 1) | 0.044 | 0.170** | 0.108** |
| | (0.078) | (0.078) | (0.053) |
| lag(Open2015Gdp, 1) | 0.120*** | -0.003 | 0.038* |
| | (0.040) | (0.030) | (0.021) |
| lag(LInterest, 1) | -0.023 | 0.106 | -0.017 |

| | | | |
|---|---|---|---|
| | (0.017) | (0.077) | (0.016) |
| lag(Reer2015, 1) | -0.001* | -0.001 | -0.0003 |
| | (0.0004) | (0.001) | (0.0003) |
| Observations | 384 | 264 | 648 |
| $R^2$ | 0.104 | 0.119 | 0.081 |
| Adjusted $R^2$ | 0.041 | 0.047 | 0.027 |
| F Statistic | 4.150*** (df = 10; 358) | 3.284*** (df = 10; 243) | 5.416*** (df = 10; 611) |

Source: Author's own calculation
Note: *p<0.1; **p<0.05; ***p<0.01; standard errors of coefficients are in brackets

Similarly, to debt variables, the control variables produce somewhat different results among subgroups. In the first group (red group) population growth rate and real exchange rate have significance at 10% level and openness indicator produce 1%. On the other hand, second group (blue group) has significance among government budget.

When running estimation with full dataset (see table 4), it produces significant result for both debt variables at 5% level. Estimated coefficients are similar to the results of each subgroup. Significance of debt variables in the whole sample confirms the theoretical understanding of debt being an important factor influencing GDP growth rate and at certain levels it starts weakening economic growth rate.

The results vary between the full group of 27 countries and the two subgroups, but despite the fact the debt variables are not always significant among all groups, the estimated coefficients point towards inverted U-shape relationship of public debt and GDP growth rate. It shows that at first debt is having positive effect on economic growth rate and after certain point its effect turns negative.

It was pointed out in literature that negative nonlinear relationship between debt and economic growth cannot be taken for granted due to reason that nonlinearity can change over time and results are dependent of underlying data. Estimations can be especially sensitive to different groups of countries and time dimensions. Also influencing factor of the results can whether annual data or multi-year averages are used (Égert, 2015). Therefore, such influential factors could have caused different results among three groups.

As the results gave out impression that debt effect on economic growth is shaped as inverse U, therefore the author calculated possible turning points for two subgroups and whole sample. The possible turning point are shown in a table 5.

Table 5. Debt level turning points

| | Group 1 (red) | Group 2 (blue) | Whole sample |
|---|---|---|---|
| Turning points | ≈ 19.4% | ≈ 109.1% | ≈ 94.2% |

Source: Author's own calculation

For the first subgroup the debt starts to have negative effect after reaching 19.4% of GDP, and second group has negative effect after reaching 109.1% of GDP. Notice again that red group did not produce any significant results and blue group significance level were at minimum 10% level. For the whole sample of countries, the debt turning point is at 94.2% level of GDP, which is quite similar to findings of Checherita-Westphal et al. (2012) and Reinhart et al (2010). Both found that on average debt starts to have negative effect after reaching 90-100% level of GDP.

For subgroups there are no similar empirical research papers. Only paper, which used same WGI data for clustering had five subgroups and nearly five times more countries included so no analogy can be drawn with it (Pereima et al., 2016). Possibly the closest resemblance are papers which have grouped countries as new or old European Union member states. For example, in a paper estimated that for old member states the turning point was in between 80%-90% and for the new member states it was about 53% (Mencinger et al., 2014), which is quite similar to results of Group 2 (blue) in this paper as many of these old members are grouped together.
Exact same results with groups are hard to find as there are no papers with an identical or almost identical subgroup. Possibly the only paper where for example very high debt threshold was found was conducted with data of Israel (Shahor, 2018). The author of this paper found threshold level of Israel to be 130%. When looking at World Bank WGI dataset (see table. 6), then Israel on average has lower score than blue group (group no. 2) in this paper, but its scores are mostly better than scores of red group (group no.1). The highest difference is score of political stability and absence of violence/terrorism (PolStabViol), which for Israel is -1.17. So, there is a possibility that threshold level of blue group might indeed be very high.

Table 6. Means of clustering result compared to Israel

| | Group | Means | Group | Means | Means (Israel) |
|---|---|---|---|---|---|
| VoiceAccount | Red | 0.905 | Blue | 1.453 | 0.673 |
| PolStabViol | Red | 0.647 | Blue | 1.085 | -1.168 |
| GovEffect | Red | 0.718 | Blue | 1.764 | 1.206 |
| RegQual | Red | 0.866 | Blue | 1.595 | 1.123 |
| RuleLaw | Red | 0.696 | Blue | 1.729 | 0.970 |
| ContrCorrupt | Red | 0.493 | Blue | 1.887 | 0.928 |

Source: Worldwide Governance Indicators, author's own calculation,

Based on the results of full sample, after debt has reached 94.2% level adding more debt will start hurting economic growth. Therefore, each time debt-to-GDP ratio is incremented by one percentage point the economic growth rate will fall on average by -0,052 percentage points, which is slightly smaller result compared to Checherita-Westphal et al. (2012) findings, where it was concluded that effect is –0.1 pp. Meanwhile for example Kumar et al. (2015) pointed out that slowdown in growth rate of GDP is around 0.2 % for each 10% increment of debt-to-GDP ratio. For red group the slowdown of economic growth was smaller. For red group after reaching certain threshold level after which each 1 percentage point increase of public debt slow economy down by -0.036 percentage points. Similarly blue group has slowdown by 0.186 percentage points. Based on these founding lower institutional quality leads to lower threshold level but negative impact on economy is smaller than among countries with higher quality, but these countries can withstand higher amounts of debt.

## 3.2 Robustness and sensitivity

The author conducted several additional robustness and sensitivity tests. These tests included removing different variables or countries and, in some cases, adding the lagged dependent variable into the model.

### 3.2.1 Robustness/sensitivity tests without lagged dependent variable

During the first two tests (table 7) all control variables, population growth and fixed capital formation were removed. In this case the debt variables produced no statistically significant results for group 1 (red group), while group 2 (blue group) results showed that debt variable was significant. Again, whole sample produced significant result for all variables, at least at the 10%

level. Even though not all groups showed significant results among variables, estimated coefficients had similar effect (positive or negative) as main results.

Table 7. Robustness tests, control variables and/or fixed capital formation removed

| **Robustness/sensitivity tests** | | | | | | |
|---|---|---|---|---|---|---|
| | *Dependent variable: Gdp2015LogGrw* | | | | | |
| | Group 1 (Red group) | Group 2 (Blue group) | Whole Sample | Group 1 (Red group) | Group 2 Blue group) | Whole Sample |
| lag(log(Gdp2015Pc), 1) | -0.042*** | -0.067*** | -0.051*** | -0.040*** | -0.061*** | -0.048*** |
| | (0.010) | (0.014) | (0.008) | (0.010) | (0.013) | (0.008) |
| lag(I(GovDebtGdp2), 1) | -0.014 | -0.059 | -0.024** | -0.013 | -0.061 | -0.023** |
| | (0.013) | (0.043) | (0.011) | (0.013) | (0.043) | (0.012) |
| lag(GovDebtGdp, 1) | 0.023 | 0.132** | 0.054** | 0.012 | 0.121** | 0.039* |
| | (0.027) | (0.060) | (0.022) | (0.025) | (0.060) | (0.021) |
| lag(FixCapForm, 1) | 0.071 | 0.136* | 0.107** | | | |
| | (0.071) | (0.072) | (0.051) | | | |
| Observations | 400 | 275 | 675 | 400 | 275 | 675 |
| $R^2$ | 0.055 | 0.110 | 0.066 | 0.052 | 0.097 | 0.059 |
| Adjusted $R^2$ | 0.008 | 0.062 | 0.022 | 0.008 | 0.052 | 0.017 |
| F Statistic | 5.511*** (df = 4; 380) | 7.994*** (df = 4; 260) | 11.318*** (df = 4; 644) | 7.014*** (df = 3; 381) | 9.389*** (df = 3; 261) | 13.524*** (df = 3; 645) |

Source: Author's own calculation
Note: *p<0.1; **p<0.05; ***p<0.01; standard errors of coefficients are in brackets

Another robustness check (see table 8) entailed the removal all control variables only. In this case group 1 (red group) results showed no results for debt variables. Debt variable significance of Group 2 (blue group) stayed the same as in baseline estimation. For full dataset the squared all debt significance stayed at 5% level. Estimated coefficients were with similar signs as main estimations.

Table 8. Robustness tests, control variables removed

| **Robustness/sensitivity tests** | | | |
|---|---|---|---|
| | *Dependent variable: Gdp2015LogGrw* | | |
| | Group 1 (Red group) | Group 2 (Blue group) | Whole Sample |
| lag(log(Gdp2015Pc), 1) | -0.038*** | -0.074*** | -0.047*** |
| | (0.010) | (0.016) | (0.008) |
| lag(I(GovDebtGdp2), 1) | -0.015 | -0.059 | -0.024** |
| | (0.013) | (0.043) | (0.011) |
| lag(GovDebtGdp, 1) | 0.018 | 0.140** | 0.046** |
| | (0.027) | (0.061) | (0.022) |
| lag(FixCapForm, 1) | 0.079 | 0.152** | 0.101** |
| | (0.071) | (0.075) | (0.051) |
| lag(PopGrw, 1) | -0.961** | 0.443 | -0.612* |
| | (0.461) | (0.550) | (0.341) |
| Observations | 400 | 275 | 675 |
| $R^2$ | 0.066 | 0.112 | 0.070 |
| Adjusted $R^2$ | 0.016 | 0.060 | 0.026 |
| F Statistic | 5.315*** (df = 5; 379) | 6.516*** (df = 5; 259) | 9.730*** (df = 5; 643) |

Source: Author's own calculation
Note: *p<0.1; **p<0.05; ***p<0.01; standard errors of coefficients are in brackets

Next test (see table 9) included removal of multiple countries. Countries which were far away from cluster centroids (see Figure 2) were removed. In red group Bulgaria, Romania, Greece, Spain and Croatia were removed. In blue group only France was removed as this had longest distance from blue group's centroid. Also, the full dataset had afore mentioned countries removed.

Table 9. Robustness tests, outlier countries removed

| **Robustness/sensitivity tests** | | | |
|---|---|---|---|
| | *Dependent variable: Gdp2015LogGrw* | | |
| | Group 1 (Red group) | Group 2 (Blue group) | Whole Sample |
| lag(log(Gdp2015Pc),1) | -0.042* | -0.189*** | -0.063*** |
| | (0.022) | (0.041) | (0.016) |
| lag(I(GovDebtGdp2),1) | -0.020 | -0.035 | -0.042* |
| | (0.029) | (0.044) | (0.023) |
| lag(GovDebtGdp,1) | 0.032 | 0.109* | 0.097** |
| | (0.054) | (0.064) | (0.038) |
| lag(FixCapForm,1) | -0.202* | 0.223*** | -0.037 |
| | (0.107) | (0.081) | (0.066) |
| lag(PopGrw,1) | 0.043 | -0.182 | -0.106 |
| | (0.549) | (0.624) | (0.416) |
| lag(GovRevGdp,1) | -0.338** | -0.241 | -0.275*** |
| | (0.142) | (0.147) | (0.095) |
| lag(GovBudget,1) | 0.064 | 0.116* | 0.145** |
| | (0.102) | (0.066) | (0.059) |
| lag(Open2015Gdp,1) | 0.019 | 0.032* | 0.009 |
| | (0.015) | (0.018) | (0.010) |
| lag(LInterest,1) | -0.098* | 0.170 | -0.061 |
| | (0.056) | (0.106) | (0.047) |
| lag(Reer2015,1) | -0.001** | -0.002*** | -0.001* |
| | (0.0004) | (0.001) | (0.0003) |
| Observations | 288 | 216 | 504 |
| $R^2$ | 0.127 | 0.226 | 0.112 |
| Adjusted $R^2$ | 0.058 | 0.156 | 0.056 |
| F Statistic | 3.870*** (df = 10; 266) | 5.764*** (df = 10; 197) | 5.973*** (df = 10; 473) |

Source: Author's own calculation
Note: *p<0.1; **p<0.05; ***p<0.01; standard errors of coefficients are in brackets

The test results of Table 9 showed that even when removing some of the outlier countries (Bulgaria, Romania, Greece, Spain, Croatia, France) from sample, it did not improve results of red subgroup. All debt variables of red subgroup stayed insignificant. In a meantime significance among blue group dropped. Debt squared variable become insignificant and debt variable dropped to 10% level. Result of full sample also changed a little bit. Debt squared variable significance dropped to 10% level.

### 3.2.2 Robustness/sensitivity test with lagged dependent variable

All upcoming robustness and sensitivity tests had lagged GDP per capita removed and it was replaced with lagged dependent variable. Also, another estimator was introduced which should address potentially rising problem of Nickell bias (bias-corrected LSDV dynamic panel estimator).

First test (see table 10) is conducted using all the variables as it was defined in baseline model. The only exception is GDP per capita as was mentioned before. When keeping all the rest of the variables the test produced mixed results when using fixed effects estimator. Debt variables of group 2 were significant while other groups produced insignificant results.

Table 10. Robustness tests, replaced initial level of GDP with lagged dependent variable

| **Robustness/sensitivity tests** | | | |
|---|---|---|---|
| | *Dependent variable: Gdp2015LogGrw* | | |
| | Group 1 (Red group) | Group 2 (Blue group) | Whole Sample |
| lag(Gdp2015LogGrw, 1) | 0.264*** | 0.089 | 0.197*** |
| | (0.067) | (0.078) | (0.048) |
| lag(I(GovDebtGdp2), 1) | -0.006 | -0.111** | -0.015 |
| | (0.013) | (0.051) | (0.012) |
| lag(GovDebtGdp, 1) | -0.011 | 0.220*** | 0.028 |
| | (0.028) | (0.075) | (0.023) |
| lag(FixCapForm, 1) | -0.114 | 0.036 | -0.027 |
| | (0.076) | (0.088) | (0.055) |
| lag(PopGrw, 1) | -0.587 | 0.103 | -0.542 |
| | (0.468) | (0.546) | (0.349) |
| lag(GovRevGdp, 1) | 0.068 | 0.066 | 0.025 |
| | (0.110) | (0.154) | (0.081) |
| lag(GovBudget, 1) | -0.141 | 0.099 | -0.039 |
| | (0.091) | (0.092) | (0.060) |
| lag(Open2015Gdp, 1) | 0.021 | -0.047** | -0.010 |
| | (0.031) | (0.022) | (0.017) |
| lag(LInterest, 1) | -0.037** | 0.088 | -0.027* |
| | (0.017) | (0.079) | (0.016) |
| lag(Reer2015, 1) | -0.001** | -0.001** | -0.001*** |

| | | | |
|---|---|---|---|
| | (0.0003) | (0.001) | (0.0002) |
| Observations | 384 | 264 | 648 |
| $R^2$ | 0.112 | 0.104 | 0.084 |
| Adjusted $R^2$ | 0.050 | 0.030 | 0.030 |
| F Statistic | $4.502^{***}$ (df = 10; 358) | $2.816^{***}$ (df = 10; 243) | $5.581^{***}$ (df = 10; 611) |

Source: Author's own calculation
Note: *p<0.1; **p<0.05; ***p<0.01; standard errors of coefficients are in brackets

Next four tests included removing all control variables, fixed capital formation and population growth or combination of above-mentioned variables. First two tests (see table 11) produced insignificant results. In some cases, even coefficients of debt variables had different effect on economic growth.

Table 11. Robustness tests, removed control variables and/or population growth and fixed capital formation

| **Robustness/sensitivity tests** | | | | | | |
|---|---|---|---|---|---|---|
| | *Dependent variable: Gdp2015LogGrw* | | | | | |
| | Group 1 (Blue group) | Group 2 (Blue group) | Whole Sample | Group 1 (Red group) | Group 2 (Blue group) | Whole Sample |
| lag(Gdp2015LogGrw, 1) | $0.190^{***}$ | $0.147^{**}$ | $0.179^{***}$ | $0.208^{***}$ | $0.162^{***}$ | $0.199^{***}$ |
| | (0.056) | (0.063) | (0.042) | (0.056) | (0.062) | (0.042) |
| lag(I(GovDebtGdp2), 1) | -0.001 | -0.037 | -0.008 | 0.002 | -0.033 | -0.006 |
| | (0.012) | (0.044) | (0.011) | (0.012) | (0.044) | (0.011) |
| lag(GovDebtGdp, 1) | -0.009 | 0.086 | 0.012 | -0.006 | 0.092 | 0.017 |
| | (0.025) | (0.061) | (0.021) | (0.024) | (0.061) | (0.020) |
| lag(FixCapForm, 1) | 0.008 | 0.017 | 0.021 | | | |
| | (0.071) | (0.073) | (0.051) | | | |
| lag(PopGrw, 1) | $-1.028^{**}$ | -0.791 | $-1.013^{***}$ | | | |
| | (0.462) | (0.480) | (0.332) | | | |
| Observations | 400 | 275 | 675 | 400 | 275 | 675 |
| $R^2$ | 0.056 | 0.059 | 0.049 | 0.044 | 0.049 | 0.035 |
| Adjusted $R^2$ | 0.006 | 0.005 | 0.003 | -0.001 | 0.001 | -0.008 |
| F Statistic | $4.507^{***}$ (df = 5; 379) | $3.249^{***}$ (df = 5; 259) | $6.663^{***}$ (df = 5; 643) | $5.813^{***}$ (df = 3; 381) | $4.447^{***}$ (df = 3; 261) | $7.853^{***}$ (df = 3; 645) |

Source: Author's own calculation
Note: *p<0.1; **p<0.05; ***p<0.01; standard errors of coefficients are in brackets

While keeping all control variables and removing either fixed capital formation or population growth rate the results were mixed (see table 12). Both combinations produced some significance among debt variables in at least one group.

Table 12. Robustness tests, removed fixed capital formation or population growth

| **Result of Whole Sample and Subgroups** *Dependent variable: Gdp2015LogGrw* | | | | | | |
|---|---|---|---|---|---|---|
| | Group 1 (Red group) | Group 2 (Blue group) | Whole Sample | Group 1 (Red group) | Group 2 (Blue group) | Whole Sample |
| lag(Gdp2015LogGrw, 1) | 0.248*** | 0.087 | 0.195*** | 0.285*** | 0.088 | 0.212*** |
| | (0.067) | (0.078) | (0.048) | (0.065) | (0.078) | (0.047) |
| lag(I(GovDebtGdp2), 1) | -0.007 | -0.112** | -0.016 | -0.004 | -0.110** | -0.014 |
| | (0.013) | (0.051) | (0.012) | (0.013) | (0.051) | (0.012) |
| lag(GovDebtGdp, 1) | 0.006 | 0.219*** | 0.032 | -0.008 | 0.217*** | 0.034 |
| | (0.026) | (0.074) | (0.022) | (0.028) | (0.073) | (0.023) |
| lag(PopGrw, 1) | -0.656 | 0.067 | -0.537 | | | |
| | (0.467) | (0.538) | (0.349) | | | |
| lag(FixCapForm, 1) | | | | -0.123 | 0.033 | -0.025 |
| | | | | (0.076) | (0.086) | (0.055) |
| lag(GovRevGdp, 1) | 0.059 | 0.040 | 0.032 | 0.067 | 0.065 | 0.020 |
| | (0.110) | (0.140) | (0.080) | (0.110) | (0.154) | (0.081) |
| lag(GovBudget, 1) | -0.113 | 0.108 | -0.039 | -0.160* | 0.100 | -0.052 |
| | (0.090) | (0.089) | (0.060) | (0.090) | (0.091) | (0.060) |
| lag(Open2015Gdp, 1) | 0.009 | -0.045** | -0.012 | 0.015 | -0.045** | -0.016 |
| | (0.031) | (0.021) | (0.016) | (0.031) | (0.020) | (0.016) |
| lag(LInterest, 1) | -0.038** | 0.087 | -0.027* | -0.037** | 0.089 | -0.026 |
| | (0.017) | (0.079) | (0.016) | (0.017) | (0.079) | (0.016) |
| lag(Reer2015, 1) | -0.001** | -0.001** | -0.001*** | -0.001** | -0.001** | -0.001*** |
| | (0.0003) | (0.001) | (0.0002) | (0.0003) | (0.001) | (0.0002) |
| Observations | 384 | 264 | 648 | 384 | 264 | 648 |
| $R^2$ | 0.106 | 0.103 | 0.083 | 0.108 | 0.104 | 0.080 |
| Adjusted $R^2$ | 0.046 | 0.033 | 0.031 | 0.048 | 0.034 | 0.027 |
| F Statistic | 4.738*** (df = 9; 359) | 3.121*** (df = 9; 244) | 6.181*** (df = 9; 612) | 4.820*** (df = 9; 359) | 3.137*** (df = 9; 244) | 5.920*** (df = 9; 612) |

Source: Author's own calculation
Note: *p<0.1; **p<0.05; ***p<0.01; standard errors of coefficients are in brackets

Using bias-corrected LSDV dynamic panel estimator mostly results were insignificant. Only exception was blue group, which produced significant result for both debt variables at 10% level (see Appendix 4).

Numerous robustness and sensitivity tests were conducted by author of this master thesis. The process included removing numerous variables and in one case adding lagged dependent variable into equation. Not all test results are shown here, because many tests produced similar results and therefore were not up for discussion. Total number of 12 robustness and sensitivity tests were conducted by author.

In conclusion robustness and sensitivity tests showed that the baseline results were not robust and are sensitive to changes in underlining data and changes in variables. Even when removing some of the outlier countries. In many cases estimated coefficients were different and not in line with a theory, which claims that debt has inverted U-shape relationship.

# CONCLUSION

The aim of this paper is to ascertain how debt levels of current European Union member are affecting their GDP growth rate and at what levels debt starts to have negative effect on the economy. Instead of approaching the subject in a manner that has been done in previous empirical papers, the author decided to group countries differently. The author created clusters of countries based on their institutional quality in order to ascertain whether countries with higher institutional quality could withstand more debt and whether they react differently to higher levels than the ones with lower quality. Based on clustering results it can be concluded that creating up to three groups would have been reasonable too, but as third group contained very small number of countries for further analyses the author used two groups in this paper.

Before continuing, Author reminds that this thesis was looking answers for three questions. Questions, which this paper tried to find answers to are:

1) Does debt have a negative effect on the economic growth?
2) At what level debt does the effect turn negative?
3) Are there different debt tolerance levels between different country clusters based on their institutional quality?

After clustering the quadratic model was estimated with time and country fixed effects. Estimations were run separately with two subgroups and with full sample. The main model produced somewhat mixed results. Red group (Group 1), which was characterized with lower institutional quality, did not produce exactly the result that author expected. The results were not significant. Meanwhile blue group (Group 2), the group with higher institutional quality, produced significant results among both debt variables. Although both subgroups estimated coefficients were according to theory and demonstrated that at some point debt will have burdensome effect on the economy. Both subgroups showed that debt in power two was with negative coefficient while debt variable was with positive sign. As previously mentioned, the same model was also estimated using the full sample of 27 countries. Results of full sample produced statistically significant results for both debt variables and estimated coefficients were according to theory.

After estimations author calculated debt turning points for full sample and for subgroups, even though subgroups produced mixed results. For full sample the debt turning point after which it has detrimental on the economic growth is around 94%. Similar level is quite frequently pointed out by many other empirical papers as this tends to be as an average level of debt threshold. Meanwhile red (group 1), which had lower institutional quality, had turning point at around 19% level. Meaning that if debt is above 19% of GDP, it has negative effect on the economy. Similarly, turning point for blue (group 2) was calculated and it showed that threshold is at 109% level.

At later stage numerous robustness and sensitivity tests were performed. Total number of 12 tests were conducted. Tests included removing or adding variables into estimation. Also, countries which had very large distance from cluster centroid were removed in one case. The tests were run in similar manner as baseline estimation, each subgroup and full sample separately. Robustness and sensitivity tests made clear that baseline estimation is not robust and is rather sensitive, which was especially evident among subgroups.

Taking all into consideration it can be concluded that debt may have inverted U-shape relationship with economic growth rate, though robustness of the results is raising some concerns. U-shape relationship was quite clear when using full sample, but not among all subgroups. There it is hard to answer whether debt has different effect among subgroups as one of the subgroups did not produce any significant results.

Debt turning point of full sample was pretty much in line with results of other empirical papers and it is worth to mention that outcome of full sample showed slightly less sensitivity than subgroups. Meanwhile group with lower institutional quality had very low debt turning point while group with higher quality had high turning point.

For future consideration one possibility is add more countries into a dataset. Especially these countries should have larger variability among institutional quality scores. Therefore, when performing clustering analyses then probably more cluster will emerge and these cluster have decent number of members in it. Having larger number of countries and more groups makes each cluster more homogenous. Running estimations on such groups might give more clear results of

debt effect on economic growth among subgroups. Also, in such case it can be more clear whether institutional quality has an effect on debt threshold levels.

# KOKKUVÕTE

## RIIGIVÕLA MÕJU MAJANDUSKASVULE EUROOPA LIIDU LIIKMESRIIKIDE NÄITEL

Mihkel Männik

Riikide võlatasemed on märkimisväärselt kasvanud viimaste kümnendite jooksul. Taoline kasv on tingitud valitsuste ekspansiivse fiskaalpoliitika mõjust ning ka Euroopal liidu liikmesriigid ei ole siinkohal erandiks. Kuigi üheksakümnendatel leppisid liikmesriigid kokku optimaalse võlataseme, mille eesmärgiks oli liidu finantsstabiilsuse säilitamine, ei ole paljud riigid sellest kokkuleppest aga kinni pidanud. Tänaseks on mitmed riigid ületanud kokku lepitud 60% võlataset (Tanzi & Schuknecht, 1997; European Central Bank, 2021).

Käesoleva magistritöö analüüsib riigivõla mõju majanduskasvule Euroopa Liidu liikmesriikide näitel ja mis tasemest alates avaldub võla negatiivne mõju. Töö kasutab antud juhul lisaks veel riikide institutsionaalseid kvaliteedi näitajad eesmärgiga välja selgitada, kas parema kvaliteediga riigid suudavad taluda kõrgemat võlataset. Samuti kas on erinevate kvaliteedi gruppide vahel võlal erinev mõju.

Autor püstitas kolm küsimust, millele otsitakse siinse magistritöö käigus vastuseid. Küsimused on järgmised:

1) Kas riigivõlal on negatiivne mõju majanduskasvule?
2) Mis tasemest alates avaldub võla negatiivne mõju?
3) Kas erinevate riigi gruppide (institutsionaalse kvaliteedi näitajate põhjal) vahel on erinevad võla taluvuse tasemed?

Autor kasutas riikide grupeerimiseks k-keskmiste klasterdamise meetodit ning andmetena institutsionaalse kvaliteedi näitajaid perioodist 1996-2021. Riigid grupeeriti kaheks, kuigi üks variant oleks olnud need grupeerida ka kolmeks, kuid sellisel juhul oleks üks grupp sisaldanud liiga vähe andmeid.

Peale klasterdamist leiti võla mõju majanduskasvule kasutades selles fikseeritud efektidega regressioon analüüsi. Sama metoodikat kasutati iga uue grupi ja ka kogu andmestiku peal. Põhimudeli tulemused olid varieeruvad. Madalama kvaliteedi näitajatega grupi tulemused ei olnud statistiliselt olulised, kuid kõrgema kvaliteediga grupiga tulemused olid. Samuti olid statistiliselt olulised ka terve andmestiku tulemused.

Kuigi kõik tulemused ei olnud statistiliselt olulised leiti töös ikkagi iga grupi ja ka kogu andmestiku maksimaalsed võlatasemed peale mida avaldub negatiivne mõju. Madalama kvaliteediga grupi puhul oli maksimaalseks tasemeks 19.4% ja kõrgema kvaliteediga grupi puhul ca 109,1%. Kogu andmestiku tulemuseks tuli 94,2%.

Peale eelnevat teostas autor ka mitmeid robustsuse ja sensitiivsuse teste. Kokku tehti 12 erinevat robustsus testi. Kokkuvõttes tulemused ei olnud robustsed ja olid tundlikud alusandmete muutumisele, millele on viidatud ka osades empiirilistes uuringutes.

Kokkuvõttes võib väita, et võla ja SKT kasvu vahel on tõenäoliselt tagurpidi U-kujuline seos. Sellegipoolest kõik tulemused ei olnud statistiliselt olulised ja ei olnud ka robustsed.

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# APPENDICES

## Appendix 1. List of variables in dataset and similar

Table 13. Variables in econometric model

| **Variable** | **Explanation** |
|---|---|
| Gdp2015LogGrw | Natural logarithm of GDP growth rate |
| log(Gdp2015Pc) | Natural logarithm of GDP per capita in 2015 prices |
| GovDebtGdp | Government debt as a percentage of GDP |
| $GovDebtGdp^2$ | Government debt as a percentage of GDP in power of 2 |
| PopGrw | Population growth rate |
| GovRevGdp | Government revenues as a percentage of GDP |
| GovBudget | Government budget as a percentage of GDP |
| Open2015Gdp | Sum of exports and imports as a percentage of GDP |
| Linterest | Long-term interest rate in a first difference |
| Reer2015 | Real exchange rate in 2015 prices |

Source: Author's own creation

Table 14. Countries names and their codes

| Code | Name |
|---|---|
| AT | Austria |
| BE | Belgium |
| BG | Bulgaria |
| CY | Cyprus |
| CZ | Czechia |
| DE | Germany |
| DK | Denmark |
| EE | Estonia |
| EL | Greece |
| ES | Spain |
| FI | Finland |
| FR | France |
| HR | Croatia |
| HU | Hungary |
| IE | Ireland |
| IT | Italy |
| LT | Lithuania |
| LU | Luxembourg |
| LV | Latvia |
| MT | Malta |
| NL | Netherlands |
| PL | Poland |
| PT | Portugal |
| RO | Romania |
| SE | Sweden |
| SI | Slovenia |
| SK | Slovakia |

Source: *Countries…*

Table 15. Worldwide governance Indicators with their name, explanation and assigned name in cluster analyses

| **Variable name** | **Assigned name** | **Description** |
|---|---|---|
| Voice and Accountability | VoiceAccount | View whether citizens can participate in their government selection, do they have freedom of expression, association, and a free media. |
| Political Stability and Absence of Violence/Terrorism | PolStabViol | Shows view of citizens of the likelihood of political instability. Including political violence and terrorism. |
| Government Effectiveness | GovEffect | View of the quality of services like public and civil service. Including their freedom from political pressures, quality of implementing politics and whether the policies are followed |
| Regulatory Quality | RegQual | Whether government is capable of implementing sound policies, which allow and promote private sector development. |
| Rule of Law | RuleLaw | Measures do citizens follow rules and whether they have confidence in them. Including quality of contract enforcement, property rights, work of the police and the courts. Also, likelihood of crime and violence. |
| Control of Corruption | ContrCorrupt | View whether there is corruption or not in the country. |

Source: Worldwide Governance Indicators

## Appendix 2. Data

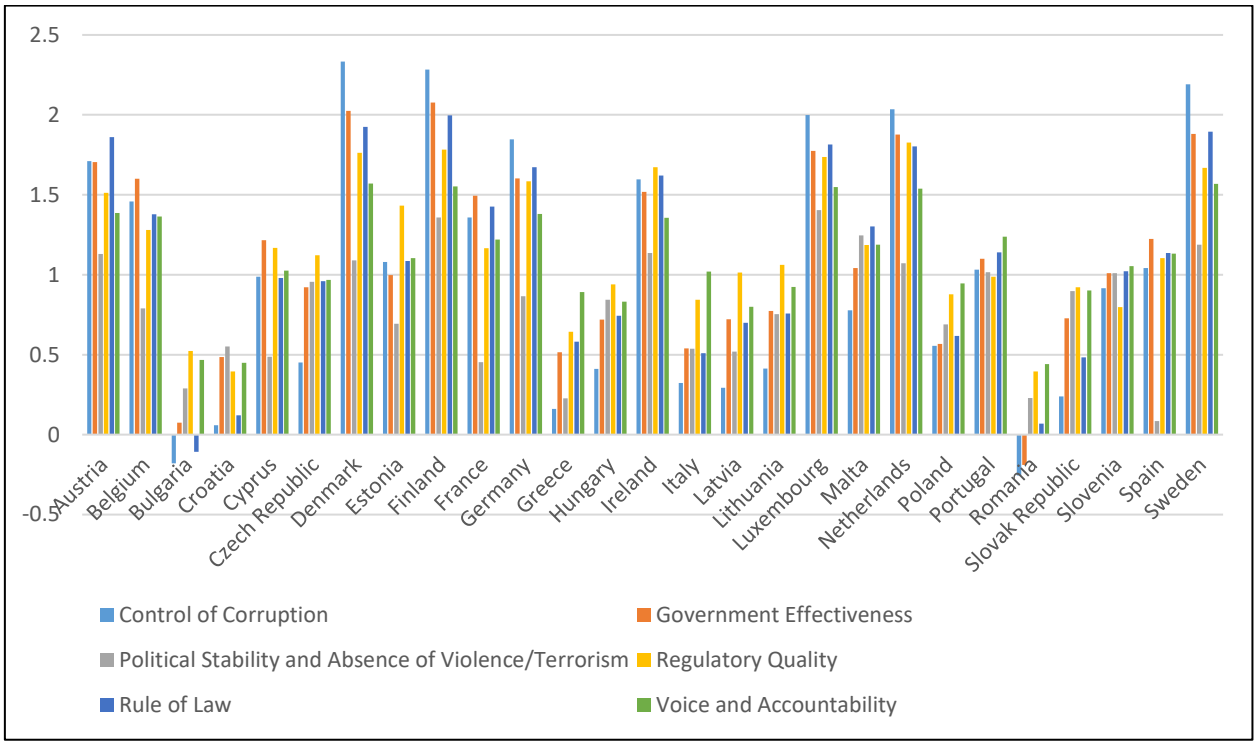


Figure 3. Averages of Worldwide Governance Indicators from 1996-2021

Source: Worldwide Governance Indicators, author's own calculations

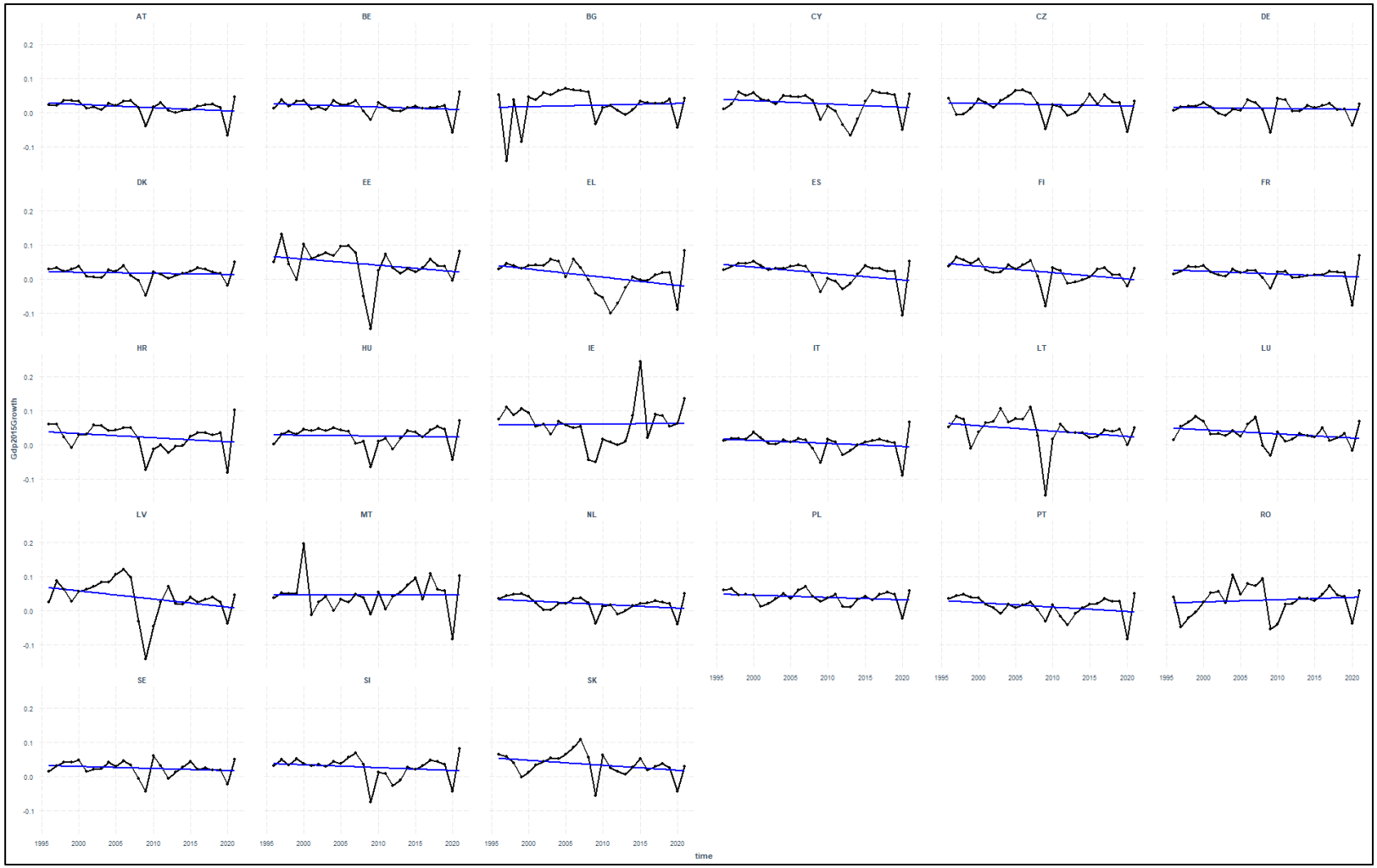


Figure 4. Debt to GDP ratio and GDP growth rate with regression line

Source: Eurostat, AMECO, World Bank, author's figure

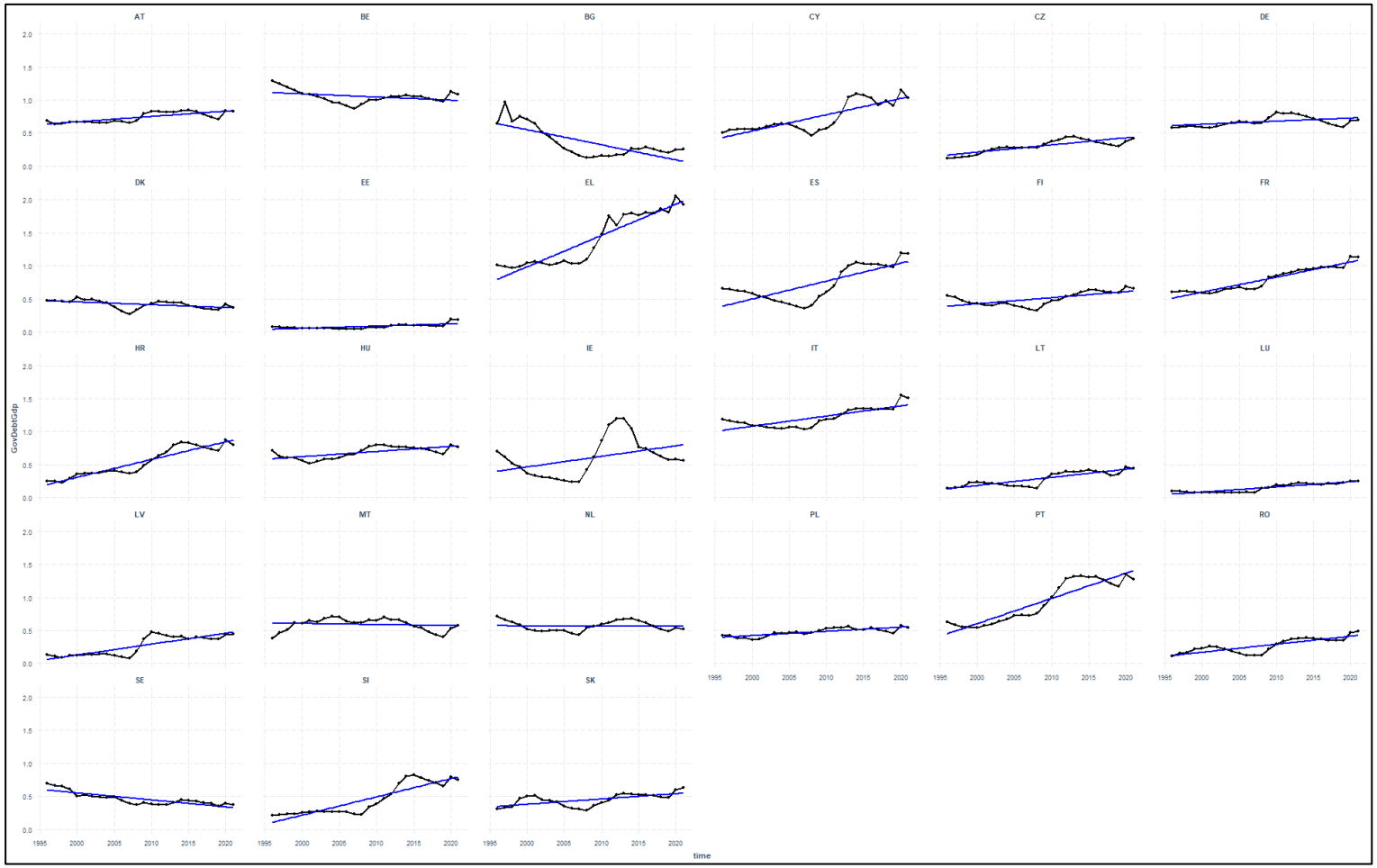


Figure 5. Debt to gdp ratio and GDP growth rate with regression line

Source: Eurostat, AMECO, World Bank, author's figure

Table 16. Each country average of Worldwide governance indicator score

| Country | Control of Corruption | Government Effectiveness | Political Stability and Absence of Violence/Terrorism | Regulatory Quality | Rule of Law | Voice and Accountability |
|---|---|---|---|---|---|---|
| Austria | 1.7103 | 1.7036 | 1.1295 | 1.5132 | 1.8602 | 1.3855 |
| Belgium | 1.4576 | 1.6004 | 0.7901 | 1.2806 | 1.3787 | 1.3647 |
| Bulgaria | -0.1794 | 0.0750 | 0.2892 | 0.5232 | -0.1071 | 0.4680 |
| Croatia | 0.0580 | 0.4856 | 0.5506 | 0.3958 | 0.1203 | 0.4501 |
| Cyprus | 0.9872 | 1.2152 | 0.4862 | 1.1677 | 0.9805 | 1.0254 |
| Czech Republic | 0.4503 | 0.9212 | 0.9550 | 1.1226 | 0.9604 | 0.9671 |
| Denmark | 2.3324 | 2.0242 | 1.0903 | 1.7622 | 1.9241 | 1.5700 |
| Estonia | 1.0800 | 0.9974 | 0.6944 | 1.4332 | 1.0866 | 1.1034 |
| Finland | 2.2830 | 2.0776 | 1.3578 | 1.7821 | 1.9965 | 1.5527 |
| France | 1.3572 | 1.4935 | 0.4532 | 1.1654 | 1.4259 | 1.2210 |
| Germany | 1.8475 | 1.6027 | 0.8661 | 1.5854 | 1.6731 | 1.3811 |
| Greece | 0.1604 | 0.5153 | 0.2271 | 0.6426 | 0.5808 | 0.8907 |
| Hungary | 0.4120 | 0.7189 | 0.8432 | 0.9403 | 0.7433 | 0.8310 |
| Ireland | 1.5969 | 1.5190 | 1.1367 | 1.6731 | 1.6210 | 1.3568 |
| Italy | 0.3223 | 0.5388 | 0.5367 | 0.8427 | 0.5087 | 1.0208 |
| Latvia | 0.2938 | 0.7223 | 0.5191 | 1.0131 | 0.6997 | 0.8005 |
| Lithuania | 0.4125 | 0.7740 | 0.7526 | 1.0621 | 0.7568 | 0.9246 |
| Luxembourg | 1.9983 | 1.7738 | 1.4046 | 1.7368 | 1.8139 | 1.5488 |
| Malta | 0.7781 | 1.0416 | 1.2458 | 1.1859 | 1.3029 | 1.1883 |
| Netherlands | 2.0348 | 1.8766 | 1.0722 | 1.8262 | 1.8036 | 1.5380 |
| Poland | 0.5547 | 0.5665 | 0.6903 | 0.8769 | 0.6181 | 0.9461 |
| Portugal | 1.0324 | 1.0999 | 1.0157 | 0.9868 | 1.1393 | 1.2373 |
| Romania | -0.2565 | -0.1901 | 0.2282 | 0.3946 | 0.0690 | 0.4418 |
| Slovak Republic | 0.2392 | 0.7273 | 0.8974 | 0.9222 | 0.4829 | 0.9018 |
| Slovenia | 0.9161 | 1.0105 | 1.0098 | 0.7968 | 1.0214 | 1.0543 |
| Spain | 1.0419 | 1.2240 | 0.0849 | 1.1042 | 1.1353 | 1.1313 |
| Sweden | 2.1915 | 1.8804 | 1.1889 | 1.6685 | 1.8948 | 1.5690 |

Source: World Governance Indicators, author's own calculations

## Appendix 3. Unit Root Tests

Table 17. Levin-Lin-Chu test for variable Gdp2015LogGrw

```
Levin-Lin-Chu unit-root test for Gdp2015LogGrw
---------------------------------------------

H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -16.5615
 Adjusted t*          -7.1838        0.0000
```

Source: Authors own calculation in STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 18. Levin-Lin-Chu test for variable Gdp2015PcLog

```
Levin-Lin-Chu unit-root test for Gdp2015PcLog
---------------------------------------------

H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t         -7.0929
 Adjusted t*          -4.5359        0.0000
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 19. Levin-Lin-Chu test for variable GovDebtGdp

```
Levin-Lin-Chu unit-root test for GovDebtGdp
---------------------------------------------------------------
H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
---------------------------------------------------------------------------
                     Statistic      p-value
---------------------------------------------------------------------------
 Unadjusted t         -6.7157
 Adjusted t*          -1.8762        0.0303
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 20. Levin-Lin-Chu test for variable GovDebtGdp2

```
Levin-Lin-Chu unit-root test for GovDebtGdp2
---------------------------------------------------------------
H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
---------------------------------------------------------------------------
                     Statistic      p-value
---------------------------------------------------------------------------
 Unadjusted t         -7.4071
 Adjusted t*          -2.3764        0.0087
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 21. Levin-Lin-Chu test for variable FixCapForm

```
Levin-Lin-Chu unit-root test for FixCapForm
---------------------------------------------------------------
H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
---------------------------------------------------------------------------
                     Statistic      p-value
---------------------------------------------------------------------------
 Unadjusted t         -9.5863
 Adjusted t*          -3.8252        0.0001
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 22. Levin-Lin-Chu test for variable PopGrw

```
Levin-Lin-Chu unit-root test for PopGrw
---------------------------------------
H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t       -11.0467
 Adjusted t*         -4.8741        0.0000
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 23. Levin-Lin-Chu test for variable GovRevGdp

```
Levin-Lin-Chu unit-root test for GovRevGdp
------------------------------------------
H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t        -8.6780
 Adjusted t*         -2.0220        0.0216
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 24. Levin-Lin-Chu test for variable GovBudget

```
Levin-Lin-Chu unit-root test for GovBudget
------------------------------------------
H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t       -13.6047
 Adjusted t*         -5.6929        0.0000
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 25. Levin-Lin-Chu test for variable Open2015Gdp

```
Levin-Lin-Chu unit-root test for Open2015Gdp
---------------------------------------------

H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t         -4.8594
 Adjusted t*          -2.8143        0.0024
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 26 Levin-Lin-Chu test for variable LInterest

```
Levin-Lin-Chu unit-root test for LInterest
------------------------------------------

H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t         -9.1293
 Adjusted t*           0.3807        0.6483
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 27. Levin-Lin-Chu test for variable Reer2015

```
Levin-Lin-Chu unit-root test for Reer2015
-----------------------------------------

H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     26

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t         -8.1122
 Adjusted t*          -2.5714        0.0051
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Table 28. Levin-Lin-Chu test for variable LInterestDiff1 (LInterest in first difference)

```
Levin-Lin-Chu unit-root test for LInterestDiff1
---------------------------------------------------------------

H0: Panels contain unit roots               Number of panels  =     27
Ha: Panels are stationary                   Number of periods =     25

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
---------------------------------------------------------------------------
                     Statistic      p-value
---------------------------------------------------------------------------
 Unadjusted t       -26.1652
 Adjusted t*         -7.4387        0.0000
```

Source: Authors own calculation using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

## Appendix 4. Bias-corrected LSDV estimator results

Table 29. Bias-corrected LSDV dynamic panel estimation of full dataset

| | *Dependent variable:* Gdp2015LogGrw | | |
|---|---|---|---|
| VARIABLES | whole sample | Group 1(red group) | Group 2(blue group) |
| Gdp2015LogGrw | 0.244*** | 0.288*** | 0.126** |
| | (-0.0364) | (-0.049) | (-0.0626) |
| GovDebtGdp2 | -0.0156 | -0.0104 | -0.0722* |
| | (-0.0111) | (-0.0139) | (-0.0425) |
| GovDebtGdp | 0.0271 | -0.00219 | 0.154** |
| | (-0.0259) | (-0.0328) | (-0.0637) |
| FixCapForm | -0.032 | -0.124 | 0.0895 |
| | (-0.0603) | (-0.0812) | (-0.0845) |
| PopGrw | -0.49 | -0.371 | -0.69 |
| | (-0.355) | (-0.47) | (-0.593) |
| GovRevGdp | 0.017 | 0.0711 | -0.0779 |
| | (-0.0768) | (-0.144) | (-0.146) |
| GovBudget | -0.0401 | -0.113 | 0.0662 |
| | (-0.0567) | (-0.0907) | (-0.0668) |
| Open2015Gdp | -0.00387 | 0.00336 | -0.0300*** |
| | (-0.00773) | (-0.0114) | (-0.0112) |
| LInterestDiff1 | -0.0310* | -0.0363* | 0.134 |
| | (-0.016) | (-0.0203) | (-0.0929) |
| Reer2015 | -0.000669*** | -0.000761*** | -0.00063 |
| | (-0.00025) | (-0.00028) | (-0.00063) |
| Observations | 648 | 408 | 240 |
| Number of countries | 27 | 17 | 10 |

Source: Author's own calculations using STATA using AMECO, Eurostat, World Bank and inter-/extrapolated data

Note: Bias correction initialized by Arellano and Bond estimator; Bias correction up to order o(1/T); *p<0.1; **p<0.05; ***p<0.01; standard errors of coefficients are in brackets

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