LISBON
SCHOOL OF
ECONOMICS &
MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTER

MONETARY AND FINANCIAL ECONOMICS

MASTER'S FINAL WORK

DISSERTATION

GOVERNMENT DEBT AND ECONOMIC GROWTH IN THE EURO AREA: AN EMPIRICAL INVESTIGATION

RICARDO REIS DA TORRE

SUPERVISOR:

ANTÓNIO AFONSO

OCTOBER - 2018

Contents

List of Figures

List of Tables

Abstract

This dissertation studies the quadratic relationship between the debt-to-GDP ratio and GDP growth rate, and attempts to find threshold levels past which an increase in debt harms growth. Observing 12 European countries from 1993 to 2017, evidence was found supporting the existence of thresholds around the 110% debt-to-GDP ratio. These thresholds are considerably higher than those found in previous research. The growth rate of the debt-to-GDP ratio was also analyzed and found to have an impact on GDP growth which might be stronger than that of the ratio itself.

1. Introduction

The recent European sovereign debt crisis brought government debt to the forefront of economic and political discussion. The large hike in both debt interest rates and government debt that affected some European countries forced many, economists or otherwise, to consider the impact that those new debt levels would have on the economy. The constraint placed on policy through the imposition of limits on government debt by the euro convergence criteria (also known as the Maastricht criteria) further reinforced the need for this reflection.

While public debt seems to have a positive influence on the growth rate at a low debt-to-GDP ratio, the relationship reverses at higher levels. A non-linear analysis should therefore be able to produce threshold levels for the debt-to-GDP ratio at which the positive influence of government debt on growth is maximized. The inclusion of data from the crisis years in this analysis allows us to observe if previous results in this area hold during a large shock to some countries' government debt levels, or if evidence is found for new threshold values. As such, this work uses a methodology largely influenced by Checherita-Westphal & Rother (2012) to analyze the same 12 countries from 1993 to 2017, and to determine how the new debt thresholds compare with their results. These countries had their public finances impacted by the sovereign debt crisis in different ways, providing a diverse and representative panel.

This dissertation is organized as follows: Section 2 is the literature review; Section 3 presents the methodology and the data; Section 4 provides the results and their discussion; Section 5 concludes.

2. Literature Review

Theoretical literature on the effect of public debt on economic growth has historically been more abundant than empirical, but that has started to change. The long-run growth model presented in Diamond (1965) looks at the influence of taxes on the capital stock when used to finance debt, which is differentiated in both internal and external debt. The conclusion is that both types of debt decrease the capital stock due to the need for tax payers to reimburse the debt service. In the context of a neoclassical growth model, and assuming constant returns to capital, Saint-Paul (1992) shows that an increase in public debt always reduces the GDP growth rate. Using an endogenous growth model to study constraints on tax collection and public debt, Aizenman et al. (2007) find that, while the flow of public expenditure raises productivity, debt used to finance it always lowers the growth rate due to the reduction in public goods spending caused by the debt service. However, public sector infrastructure spending may not decrease welfare for infrastructure-poor countries, even if financed through debt. Also using an endogenous growth model, Greiner (2013) finds that, assuming wage rigidity, public debt cannot influence long-run growth rates. Surveying both theoretical and empirical literature, Panizza & Presbitero (2013) find that evidence for the existence of thresholds is still ambiguous, but do support Kourtellos et al. (2013) in their finding that it may be the quality of a country's institutions that determines how the debt-to-GDP ratio impacts growth.

Empirical studies on this matter have differed in time span, number and type of countries, and methodology. Works that observe a very large group of countries, such as Schclarek (2004) and Afonso & Jalles (2013), find that growth rates in OECD and emerging countries relate differently to public debt. Due to this difference, other studies tend to focus on euro area or select OECD countries. Checherita-Westphal & Rother (2012) observe 12 euro area countries from 1970 to 2008 and find evidence of debt turning points around a 90%-100% debt-to-GDP ratio, with confidence intervals warning that a negative effect could be experienced at a ratio as low as 70%. Baum et al. (2013) analyse the same 12 euro area countries for a fraction of that time span, 1990 to 2010, and find thresholds near 72%. However, when the financial crisis years of 2008-2010 are omitted, thresholds lower considerably to about 67% of GDP. In addition, they show that debt-to-GDP ratios above 70% place upwards pressure on long-term interest rates. Afonso & Jalles (2014) study 14 European countries between 1970 and 2012, finding an average debt threshold of about 75%. Moreover, they find that debt service has a much more negative effect on growth than debt itself. Woo & Kumar (2015) observed a mix of 38 developed and developing countries from 1970 to 2008, and found evidence suggesting that a threshold exists somewhere around the 90% debt-to-GDP ratio, but did not pinpoint an exact value. When observing a similar sample of 40 mixed countries from 1965 to 2010, Chudik et al. (2017) do not find a homogeneous threshold that can be applied to countries in all stages of development, but do find thresholds of 80% for developed economies, and around 30-60% for developing economies. Cecchetti et al. (2011) analyze 18 OECD countries from 1980 to 2010 and find a threshold around a 85% ratio of government debt-to-GDP. They go on to search for thresholds using other types of debt, such as corporate debt and household debt, with similar results.

The findings obtained by longer term studies in this area are marked by the observation of data originating from a framework that no longer exists. In the past 25 years, the European Union has changed dramatically with the establishment of a monetary union and the Stability and Growth Pact – changes that may

Table 1: Summary Empirical Literature Review

	Time		Countries			Development		Average
	<=25 Years	>25 Years	Single	2 to 15	>15	Developed	Developing	Threshold
Afonso & Jalles (2013)		X			X	X	X	59%[1]
Afonso & Jalles (2014)		X		X		X		75%
Schclarek (2004)		X			X	X	X	–
Checherita-Westphal & Rother (2012)		X		X		X		95%
Baum et al. (2013)	X				X	X	X	72%
Spilioti & Vamvoukas (2015)		X	X			X		110%
Woo & Kumar (2015)		X			X	X	X	90%[1]
Chudik et al. (2017)		X			X	X	X	80%
Cecchetti et al. (2011)		X			X	X	X	85%

Notes: [1] Threshold obtained by sampling both developed and developing countries.

have shifted the nexus between debt and growth for the euro area. However, newer observations for this region are very much influenced by the European sovereign debt crisis, which may lead to results that cannot be generalized for other periods. Thus, it is not clear which time span is to be preferred.

Given the diversity of literature observing euro area countries, some of these works look at key region-specific frameworks that condition the relationship between debt and growth. Afonso & Alves (2015) find that the Stability and Growth Pact had a small but positive effect on growth, while no discernible effect was found to be attributable to the Maastricht Treaty.

Research focusing on a single country is not as common, but it does exist. Spilioti & Vamvoukas (2015) perform a time series analysis using 40 years of Greek data and find evidence supporting the existence of a threshold effect at the 110% debt-to-GDP ratio. This type of work can explore effects specific to a single country, such as public infrastructure, which condition the type of public spending causing an increase in debt. By restricting the observations to a single country, an even greater control of the changes in the underlying framework is possible.

It should be mentioned that literature concerning exclusively develop-

ing countries sometimes focuses on external debt, rather that internal or total debt. This type of research is much less frequently applied to developed countries, where foreign debt appears to bear no impact on economic growth[1]. Ward et al. (2002) analyze 93 developing countries throughout 29 years and find that, past a debt-to-GDP ratio of 20%, additional increases in debt show a negative effect on output. These thresholds are much lower than those found for developed countries, a result that is in line with other literature, as mentioned earlier.

A short summary of empirical studies can be found in Table 1, which separates previous research by time span, number, and type of countries sampled. It also presents an average debt threshold, whenever a comparable model is available. While this value should by no means be the focus of attention, it provides a starting point for a quick comparison.

[1] Ferreira (2014)

3. Methodology and Data

This work samples a panel of 12 European countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain) from 1993 to 2017 in order to observe the impact of the debt-to-GDP ratio in GDP growth, and to calculate threshold points past which an increase in said ratio leads to a negative effect on growth. It intends to expand the analysis of Checherita-Westphal & Rother (2012) with the crisis period of 2008-2017 in order to verify whether the extreme conditions of this period confirm the thresholds found in their work, or if the limits themselves have changed. Beginning the observations in 1993, rather than 1970, as in the original paper, limits the amount of profound structural changes that influence our data, such as the Maastricht treaty, which necessarily impacts results.

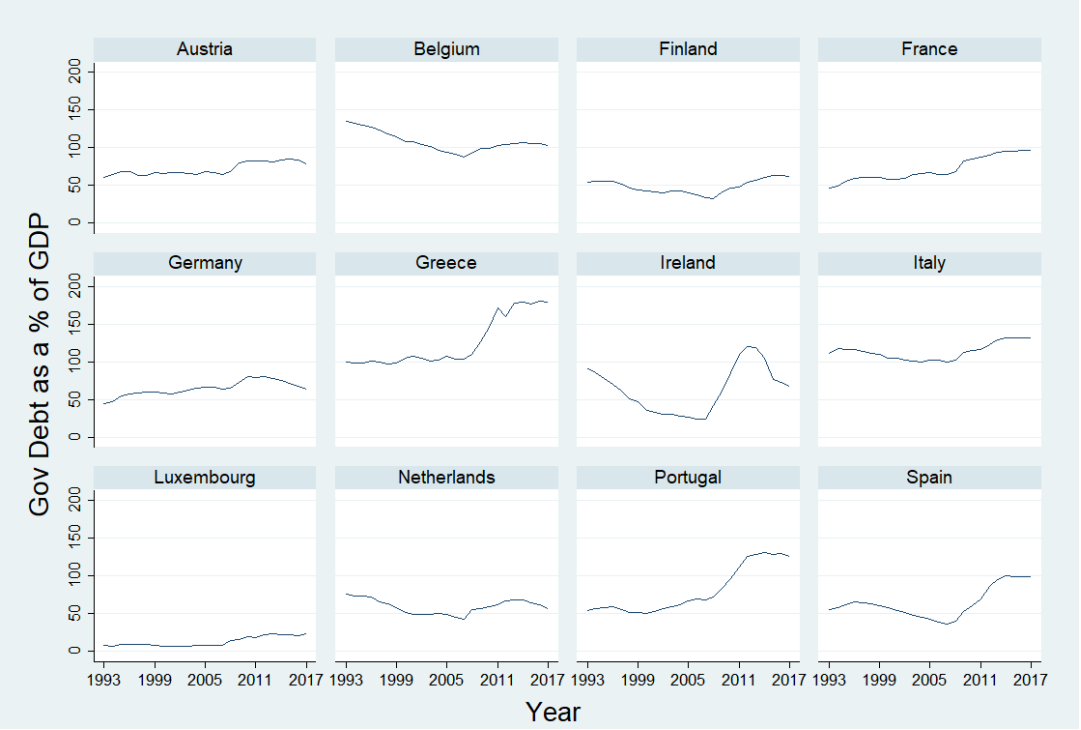
Data was obtained from the European Commission's AMECO database. A comprehensive description of the data used can be found in appendix A. The main variables of interest are summarized in Table 2 and Figure 1.

Table 2: Summary description of the main variables.

Variable	Obs	Mean	Min	Max
$Government\ Debt$	300	74.176	6.941	180.832
$GDP\ Growth$	300	1.531	-8.999	24.816

Note: Both variables shown as percentage of GDP. GDP Growth calculated based on real *per capita* GDP.

Figure 1: Government debt as a ratio of GDP for the panel sampled.



The main models used mostly follow the choices of Checherita-Westphal & Rother (2012), with small changes. Debt is represented as a quadratic equation in order to calculate threshold levels. Linear models were also estimated and shown to be much worse fits. Three dependent variables were used – real GDP *per capita* annual growth rate, 5 year cumulative real GDP *per capita* growth rate, and 5 year cumulative non-overlapping real GDP *per capita* growth rate.

The basic model follows:

$$GDPgrowth_{i,t+k} = \alpha + \beta_1 debt_{i,t} + \beta_2 debt_{i,t}^2 + \gamma ln(GDP/cap)_{i,t} + \delta gfcf_{i,t} + \phi popgrowth_{i,t} + othercontrols_{i,t} + \mu_i + v_t + \epsilon_{i,t} \quad (1)$$

Where $GDPgrowth_{i,t+k}$ is the real GDP *per capita* growth rate for country i at time t plus k where $k = 1$ for annual dependent variables and $k = 5$ if the dependent variable is a cumulative 5 year growth rate; $ln(GDP/cap)_{i,t}$ is the logarithm of GDP *per capita*; $debt_{i,t}$ is gross debt as a percentage of GDP, while $debt_{i,t}^2$ is its square value; $savings/gfcf_{i,t}$ is the investment rate as a share of GDP,

which attempts to proxy gross fixed capital formation; $popgrowth_{i,t}$ is the percentage growth rate of the population; $othercontrols_{i,t}$ are the cyclically adjusted government revenue, the cyclically adjusted budget balance, openness, and the long term real interest rate; μ_i are the country fixed effects; v_t are the time fixed effects; and $\epsilon_{i,t}$ is the error term.

Preliminary testing reveals that GPD growth *per capita* is non-stationary, and a Wooldridge test firmly suggests autocorrelation. Due to this, all regressions were performed using lagged explanatory variables – one period in the case of annual and non-overlapping dependent variables; five periods when the overlapping growth rate was used as dependent variable. A Hausman test confirms that, for our models, fixed effects should be used over random effects. These tests can be found in detail in Appendix B. In order to control for heteroskedasticity, and unobservable correlations between explanatory variables and GDP growth rate, standard errors were clustered on country. This choice does not follow Checherita-Westphal & Rother (2012), and accounts for larger standard errors, as correcting for error clustering removes a downward bias on their calculation[2]. It follows that the debt threshold confidence intervals calculated should also widen due to this methodological choice.

[2] Colin Cameron & Miller (2015)

4. Empirical Analysis

4.1 Baseline Model

Table 3 shows an estimation of the base model and variations using fixed effects. The dependent variable used is a simple annual growth rate for the first two models, a cumulative 5 year ”rolling window” overlapping growth rate for the middle two, and a cumulative 5 year non-overlapping growth rate for the final two. The explanatory variables are lagged one period for the annual growth rate and the 5 year non-overlapping models, while five periods of lag were used for the 5 year overlapping models, in order to account for autocorrelation. When compared to Checherita-Westphal & Rother (2012), the coefficients regressed mostly maintain their signal, size, and statistical significance. The changes are chiefly the loss of statistical significance for the openness and gross fixed capital formation variables, and the rise in significance of the long term real interest rate and the savings variables. In these estimates, no control variable remains statistically significant across all models.

As expected, we find the debt-to-GDP ratio to have a positive linear effect on growth, but a negative quadratic term, both highly significant across all models. This allows the calculation of a debt turning point - a threshold past which an increase in the debt-to-GDP ratio causes a decline in growth. The thresholds obtained with these models, averaging 105%, are similar to those found by

Checherita-Westphal & Rother (2012), but with much wider confidence intervals[3]. These broader confidence intervals are likely caused by the clustering of standard errors, and, possibly, more extreme differences in growth rates and debt ratios observed during the crisis years. This possibility will be further explored by restricting the countries sampled.

Table 3: Fixed Effects Models

	Annual Growth Rate		Cumulative 5 Year Overlapping Growth Rate		Cumulative 5 Year Non-Overlapping Growth Rate	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
gov_debt	.1248963 ***	.1151481 ***	.55848 ***	.65075 **	.54595 ***	.43644 **
	(.0283954)	(.0346088)	(.17965)	(.22079)	(.16929)	(.15741)
gov_debt^2	-.0006184 ***	-.0006092 ***	-.00275 ***	-.00257 ***	-.00304 ***	-.00235 **
	(.0001757)	(.0001807)	(.0006927)	(.0006312)	(.0005956)	(.0008724)
gov_rev_ca	-.0022968	.042245	-.8274248	-.8528041	-.1513821	.9825509
gov_cab	.2106793 ***	.1852265 ***	-.166643	-.7861764 ***	2.160811 ***	1.434566
$lgdp\_cap$	-5.460674	-4.549201	-64.20117 **	-75.90861 ***	22.65	13.72224
pop_g	-1.969517 **	-1.79758 *	-2.938267	-4.14432 *	-8.474897 **	-8.313057 **
$pgfcf\_total$	.0961038	–	–	–	–	–
$gfcf\_gov$	–	-.3424112	-1.870243	–	.7740059	–
$gfcf\_priv$	–	.044994	.1011784	–	.280357	–
$psaving\_gov$	–	–	–	1.936305 **	–	.6180494
$psaving\_priv$	–	–	–	.5624901 *	–	1.113293 **
$openness$	1.504972	1.548598	7.650795	8.038124	5.728421	9.868241
LT_real_i	-.1476701 ***	-.1690243 ***	.0258798	.2353467 *	-.5878332	-.9421007 *
N	267	267	219	219	60	60
$Clusters$	12	12	12	12	12	12
$R^2 - within$	.659321	.6602253	.8309056	.8628612	.8454224	.8652234
$Debt\ Turning\ Point$	100.9907	94.51074	101.71	126.8105	90.00875	115.8877
$CI\ 95\%$	[64.7; 137.3]	[64.4; 124.6]	[61.4; 142.0]	[78.4; 175.2]	[55.5; 124.3]	[58.1; 127.8]

Notes: Estimated coefficients are marked according to significance level – *10%, **5%, ***1%. Standard errors are reported in brackets for the most relevant variables. The dependent variable is the annual real GDP *per capita* growth rate for the first two models, a 5 year overlapping sum of the same variable for the middle models, and a 5 year non-overlapping sum for the final two. A comprehensive description of each variable can be found in Appendix A. Debt Turning Point, the debt threshold, is calculated as the maximum of an inverse-U shaped parabola, here given by $-gov\_debt/2gov\_debt^2$.

[3]The confidence intervals shown were calculated using the delta method, as implemented by the *nlcom* Stata command.

Table 4: Quadratic and Linear Comparisons for the Fixed Effects Models

	Annual Growth Rate		Cumulative 5 Year Overlapping Growth Rate		Cumulative 5 Year Non-Overlapping Growth Rate	
	Model 2	Model 2 (L)	Model 3	Model 3 (L)	Model 5	Model 5 (L)
gov_debt	.1151481 ***	.002772	.5584808 ***	.0547493	.5459541 ***	-.0185661
gov_debt^2	-.0006092 ***	–	-.0027455 ***	–	-.0030379 ***	–
gov_rev_ca	.042245	-.0841216	-.8274248	-.8559549	-.1513821	-.6789814
gov_cab	.1852265 ***	.064196	-.166643	-.5589307	2.160811 ***	1.216989 **
$lgdp\_cap$	-4.549201	-8.247224 **	-64.20117 **	-83.78904 **	22.65	6.436087
pop_g	-1.79758 *	-1.949278 *	-2.938267	-4.14424	-8.474897 **	-9.76879 **
$gfcf\_gov$	-.3424112	-.608104 **	-1.870243	-2.17104	.7740059	.5785746
$gfcf\_priv$	.044994	.0997866	.1011784	-.0001479	.280357	.4431192
$openness$	1.548598	2.491839	7.650795	11.78209	5.728421	9.553172
LT_real_i	-.1690243 ***	-.3020741 ***	.0258798	-.5372598 **	-.5878332	-1.18571
N	267	267	219	219	60	60
$Clusters$	12	12	12	12	12	12

Notes: Estimated coefficients are marked according to significance level – *10%, **5%, ***1%. The dependent variable is the annual real GDP *per capita* growth rate for the first two models, a 5 year overlapping sum of the same variable for the middle models, and a 5 year non-overlapping sum for the final two. A comprehensive description of each variable can be found in Appendix A.

In order to justify the use of non-linear models, the linear form of three models presented earlier was estimated and can be found in Table 4. It confirms that a quadratic approach should be preferred. In the linear models, the debt-to-GDP ratio loses all statistical significance. The only significant variables present in the linear models regressed are the logarithm of the *per capita* GDP, the population growth rate, the government's share of gross fixed capital formation , and the long term interest rate, which exhibit a similar behavior to that shown in quadratic models. No known literature suggests that other polynomials would provide a better fit, therefore none were estimated.

Due to the endogeneity between the debt ratio and GDP growth, models were also regressed using instrumental variables, which are displayed in Table 5. Two types of instruments were used: an average of the debt-to-GDP ratio of

Table 5: Instrumental Variable Models

	Annual Growth Rate		Cumulative 5 Year Overlapping Growth Rate		
	Model 1	Model 2	Model 3	Model 4	Model 5
Instruments	Avg.	Lags(1-5)	Avg.	Lags(1-5)	Avg.
Estimator	2SLS	2SLS	2SLS	GMM	GMM (h.a.)
gov_debt	.0905116 **	.1460957 ***	1.102967 ***	.5325532 ***	1.102967 ***
gov_debt^2	-.0003768 *	-.0005279 ***	-.0047922 **	-.0030316 ***	-.0047922 **
gov_rev_ca	-.0407788	-.0895344	-1.590251 ***	-.372002	-1.590251 **
gov_cab	-.0074936	.0093712	-.2687871	-1.083518 ***	-.2687871
$lgdp\_cap$	-7.618454 **	-7.599396	-66.87787 ***	-108.6424 ***	-66.87787 ***
pop_g	-2.056797 ***	-1.66419 ***	-1.807385	-4.203129 ***	-1.807385
$saving\_gov$	.4089242 ***	.4770598 ***	1.807992 ***	2.190279 ***	1.807992 ***
$saving\_priv$	.120874 *	.1067959	.0882808	.3259716 *	.0882808
$openness$	1.687958	.3598249	-.3752346	8.271588 **	-.3752346
LT_real_i	-.1773575 **	-.195049 ***	.5296739	.4258041 *	.5296739
$Country\ Dummies$	Included	Included	Included	Included	. Included
$Year\ Dummies$	Included	Included	–	Included	–
N	267	228	219	228	219
$R^2 - Adj$	.653908	.6344236	.7820432	.8637818	.7820432
$rk\ LM$	1.53e-11	7.70e-10	.0000712	7.70e-10	.0131274
$Hansen\ j$	–	.0407957	–	.0000349	–
$Threshold$	120.1069	138.3708	115.08	102.6641	115.08
$CI\ 95\%$	[68.9; 171.3]	[74.3; 197.1]	[77.7; 152.5]	[73.4; 131.9]	[70.0; 160.2]

Notes: Estimated coefficients are marked according to significance level – *10%, **5%, ***1%. The dependent variable is the annual real GDP *per capita* growth rate for the first two models, and a 5 year overlapping sum for the latter three. A comprehensive description of each variable can be found in Appendix A. The instruments used were the average value of debt of all other countries, for the models marked as Avg., and up to 5 lags of gov_debt and gov_debt^2 for the models marked Lags(1-5). Estimators used were 2SLS, two-step GMM, and two-step GMM with heteroskedasticity and autocorrelation-consistent statistics for the model marked GMM (h.a.).

each other sampled country for that year; and the country's own debt lagged up to 5 periods for overlapping dependent variables. Non-overlapping models were omitted due to low statistical significance, likely caused by the small number of observations, and can be found in Appendix B, in Table B.5. Estimators were computed through 2SLS, two-step GMM, and two-step GMM with heteroskedasticity and autocorrelation-consistent statistics.

Unlike the fixed effects models, here we see a significant increase in the threshold values when compared to Checherita-Westphal & Rother (2012), with an average threshold of 118%. The confidence intervals have also widened considerably, a change that cannot be attributed to the clustering of standard errors, which was not performed for these regressions. The bottom limit of the confidence intervals fell to around 70%, which is a slightly more conservative value than that presented in the original paper, but one that must be interpreted as part of a much wider band.

4.2 Robustness Tests

Table 6 shows the effects of removing each country from the panel. Removing countries with more extreme values of debt and/or growth causes large shifts in the threshold and in the width of the confidence interval. As expected, removing countries with more extreme debt-to-GDP values, like Greece and Luxembourg, causes large shifts in the debt threshold. However, both cause the threshold to increase, unlike the removal of a high-debt and high-growth country, such as Ireland.

We can clearly see the role of Ireland and Greece in the models where they are absent. Greece brings the overall threshold down and serves as a warning to the problems of a high debt-to-GDP ratio. Moreover, if Greece is removed from the sample, the 95% confidence interval widens to such an extent that real

world implications become hard to draw. On the other hand, Ireland is able to maintain both a high debt level and high growth, significantly raising the threshold by itself. Placing a restriction on any country other than these three does not have a strong impact on the thresholds obtained.

Table 6: Country Restricted Models

	None	BE	DE	IE	GR	ES	FR	IT	LU	NL	AT	PT	FI
gov_debt	.1248963 ***	.1321635 ***	.1208763 ***	.0920309 ***	.1154685 ***	.1297077 ***	.1264146 ***	.1275531 ***	.1561373 ***	.1244521 ***	.1199424 ***	.1475502 ***	.1475502 ***
gov_debt^2	-.0006184 ***	-.0006131 **	-.000604 ***	-.0005418 ***	-.0004634 *	-.0007285 ***	-.0006427 ***	-.0006321 ***	-.0006934 ***	-.0006227 ***	-.0006029 ***	-.0007228 ***	-.0007228 ***
gov_rev_ca	-.0022968	-.0335313	-.0063884	.0723131	-.0809923	-.0371211	.0268674	.0120345	.0328776	-.0137755	.0256092	.0976754	.0976754
gov_cab	.2106793 ***	.2150148 ***	.1924728 ***	.2625837 ***	.1822151 ***	.2269205 ***	.2129464 ***	.2087164 ***	.2407689 ***	.2155999 ***	.2001418 ***	.2139377 ***	.2139377 ***
$lgdp\_cap$	-5.460674	-5.598021	-5.906311	-10.80794 ***	-4.555803	-6.13688	-4.568092	-4.781672	-11.43136 ***	-5.500864	-5.636805	-3.965374	-3.965374
pop_g	-1.969517 **	-1.956299 *	-2.013513 **	-1.166761 *	-1.665539 *	-2.711763 ***	-1.985581 **	-1.97775 **	-1.536169 *	-1.950628 *	-2.167044 **	-2.003404 **	-2.003404 **
$gfcf\_total$	.0961038	.113906	.1028013	.0024824	.1507603 *	.0444133	.0814237	.0865098	.1962683 *	.084608	.1525845 *	.0607266	.0607266
$openness$	1.504972	1.496379	1.545301	.8522305	.8783497	1.584077	1.436013	1.520183	9.39005 ***	1.485061	1.658573	1.348008	1.348008
LT_real_i	-.1476701 ***	-.1438504 **	-.1317941 ***	-.2214485 ***	-.1705418 **	-.1265979 **	-.1380264 **	-.1481158 ***	-.1560643 ***	-.1451941 **	-.1337809 **	-.1558024 ***	-.1558024 ***
$Clusters$	12	11	11	11	11	11	11	11	11	11	11	11	11
$R^2 - within$	.659321	.66624	.6574716	.7625689	.677922	.6675625	.6595987	.6489557	.6838034	.6505958	.6599115	.6594482	.6594482
$Threshold$	100.9907	107.7751	100.0616	84.93124	124.5777	89.02178	98.33933	100.8959	112.5895	99.92182	99.47069	102.0652	97.0074
$CI\ 95\%$	[64.7; 137.3]	[55.9; 159.7]	[63.4; 136.8]	[52.1; 117.8]	[61.4; 187.7]	[66.8; 111.2]	[60.2; 136.4]	[64.3; 137.5]	[78.4; 146.8]	[57.4; 142.4]	[62.2; 136.8]	[69.6; 134.5]	[61.6; 132.4]

Notes: Estimated coefficients are marked according to significance level – *10%, **5%, ***1%. All estimations are variants of the first FE model, presented in the first column, where one country was removed from the sample.

Table 7 shows the fixed effects models presented earlier expanded to include the variation of the debt-to-GDP ratio from one year to the next, in percentage. This variable is highly significant in the models where the dependent variable is annual. The negative coefficient estimated for the debt-to-GDP ratio's growth rate follows expectations. These models suggest that an increase of 1% in the growth of the debt-to-GDP ratio – that is, an acceleration of 1% – would, on average, cause a decrease of 0.045 percent points in GDP growth. When applied to the most extreme example in our panel, Ireland's 77.3% increase in debt-to-GDP ratio in 2008, this effect could, by itself, explain a fall of about 3.5% in GPD.

The magnitude of the effect is relatively large when compared to changes in the ratio near the turning point, as can be seen in the simulation presented in Table 8. For example, a change in the debt-to-GDP ratio from 100% to 120% would be almost offset by a fall of 0.5% in the ratio's growth rate, assuming the debt ratio was stable before. This implies that, for a country with a debt-to-GDP ratio reasonably close to the turning point, changes in the ratio's growth rate are estimated to be a more important determinant of GDP growth than a variation in the ratio itself. From a public policy standpoint, this result suggests that the ratio's growth rate should be considered an important indicator of GDP *per capita* growth. This variable loses much of its statistical significance in the 5 year overlapping models, where the annual dynamics of debt are being lost along the 5 year period. Moreover, the ebb and flow of the ratio's variations are likely to blunt much of the effect of one year's change in debt over the five following years.

When countries are divided according to their position as either periphery countries (Greece, Ireland, Italy, Portugal, and Spain) or core countries (Austria, Belgium, Finland, France, Germany, Luxembourg, and the Netherlands), no reliable debt threshold can be obtained for the core countries (see Table 9). The turning point obtained when only periphery countries are considered is lower when computed through a fixed effects model (79% down from around 90%), but higher when obtained via an IV model (123% up from an average of 118%). It is not

Table 7: Fixed Effects Models With Debt-to-GDP Ratio Growth

	Annual Growth Rate		Cumulative 5 Year Overlapping Growth Rate		Cumulative 5 Year Non-Overlapping Growth Rate	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
gov_debt_gr	-.0460309 ***	-.0451038 ***	-.0398533	-.0092925	-.4251153 ***	-.4806182 ***
gov_debt	.1233354 ***	.1192487 ***	.5812255 ***	.6546546 **	.2578243 **	.4766291 ***
gov_debt^2	-.0006186 ***	-.000621 ***	-.0028433 ***	-.0025881 ***	-.0018827 **	-.0027208 ***
gov_rev_ca	-.00538	.0215496	-.8847254	-.8526612	.8235205	.6397749
gov_cab	.157398 **	.1452122 **	-.1855201	-.7846983 ***	.3177782	-.1153744
$lgdp\_cap$	-5.796957	-5.256643	-64.38237 **	-75.65301 ***	25.89347 *	14.62003
pop_g	-1.890508 **	-1.790112 **	-2.908369	-4.093713 *	-8.613093 ***	-11.64401 ***
$gfcf\_total$	.08575	–	–	–	–	–
$gfcf\_gov$	–	-.1864465	-1.731435	–	-1.372229	–
$gfcf\_priv$	–	.0458388	.1342049	–	-.4289342	–
$saving\_gov$	–	–	–	1.916585 **	–	1.87497 ***
$saving\_priv$	–	–	–	.568903 *	–	.4641974 **
$openness$	1.573706	1.646186	8.356932	8.187485	-5.688223	-7.222996 *
LT_real_i	-.0979079	-.1135632	.1012957	.2480514	-1.072219 *	-.5903108
N	267	267	219	219	60	60
$Clusters$	12	12	12	12	12	12
$R^2 - within$	.6757315	.675616	.8319213	.8629141	.9069938	.9347916
$Threshold$	99.7	96.0	102.2	126.5	68.5	87.6
$CI\ 95\%$	[69.0; 130.3]	[69.2; 122.8]	[63.5; 140.9]	[77.1; 175.8]	[49.9; 87.0]	[67.4; 107.8]

Notes: Estimated coefficients are marked according to significance level – *10%, **5%, ***1%. The dependent variable is the annual real GDP *per capita* growth rate for the first two models, a 5 year overlapping sum of the same variable for the middle models, and a 5 year non-overlapping sum for the final two.

Table 8: Interaction Between the Debt-to-GDP Ratio and its Growth Rate

Debt Ratio	Impact	Debt Ratio Growth	Impact	GDP Growth
	5.173	-0.5	0.2301	5.403
60	5.173	-1	0.4603	5.633
	5.173	-3	1.3809	6.554
	5.907	-0.5	0.2301	6.137
80	5.907	-1	0.4603	6.368
	5.907	-3	1.3809	7.288
	6.147	-0.5	0.2301	6.377
100	6.147	-1	0.4603	6.607
	6.147	-3	1.3809	7.528
	5.892	-0.5	0.2301	6.122
120	5.892	-1	0.4603	6.352
	5.892	-3	1.3809	7.273
	4.581	-0.5	0.2301	4.811
150	4.581	-1	0.4603	5.042
	4.581	-3	1.3809	5.962

Notes: This simulation was calculated using the baseline annual growth rate fixed effects model expanded with the growth rate of the Debt-to-GDP ratio (Table 7 Model 1). Debt Ratio presented as a percentage of GDP. Impact refers to the effect of each variable on GDP growth. Values for Debt Ratio Growth presented as a percentage of the Debt-to-GDP ratio.

Table 9: FE and IV Models Divided in Periphery and Core Countries

	Fixed Effects		2SLS IV 1-5 Lags	
	Periphery	Core	Periphery	Core
gov_debt	.141077 **	.0180168	.2440811 ***	-.0505404
gov_debt^2	-.0008883 **	-.0000509	-.0009919 ***	.0000857
gov_rev_ca	.3314599	.006875	-.2954842	-.3492951 ***
gov_cab	.1524185	.1909383	-.0193863	.4339063 ***
$lgdp\_cap$	-12.93679 **	-16.82082 **	-6.488499	-28.43502 ***
pop_g	-2.163332	-.6155736 *	-1.896732 ***	-.7732328 *
$saving\_gov$	–	–	.8818154 ***	-.0440411
$saving\_priv$	–	–	-.0065938	-.061608
$openness$	13.12077 **	.649831	1.628682	-1.176155 *
LT_real_i	-.0390448	-.0502908	.0409909	-.0435499
N	110	157	95	133
$R^2 - Adj$	.6075888	.7842052	.6466616	.8199139
$rk\ LM$	–	–	.0016015	.0000455
$Hansen\ j$	–	–	.7711385	.1190433
$Debt\ Turning\ Point$	79.4	–	123.0	–
$CI\ 95\%$	[43.8; 115.0]	–	[84.8; 161.3]	–

Notes: Estimated coefficients are marked according to significance level – *10%, **5%, ***1%. The dependent variable is the annual real GDP *per capita* growth rate for all models. Periphery countries were defined as Greece, Ireland, Italy, Portugal, and Spain, while all other sampled countries were considered core.

easy to discern a concrete cause for this ambiguous effect. The absence of a clear debt threshold for the core European countries could be explained by an extension of the distinction between developed and developing countries into a continuous progression, rather than a strict dichotomy. Either way, further study would be required to accurately comprehend this result.

Expansions including a dummy specific for the crisis years[4], and the introduction of the debt-service-to-GDP ratio[5] were attempted, but did not expand the explanatory power of the model. For the crisis variable this may be due to the inclusion of yearly dummies that already capture the effects specific to that period. The debt service effect may already be captured by the interaction between the debt-to-GDP ratio and the interest rate. Possible further expansions could attempt to estimate similar models using debt held by the public as an explanatory variable, rather than total debt.

[4] Table B.6
[5] Table B.7

5. Conclusions

While the sovereign debt crisis has passed, it has left some European countries with large amounts of debt whose effects on growth still remains a point of contention. In this work, 12 euro area countries were analyzed from 1993 to 2017 using a non-linear methodology . The time span showed an increase in the debt thresholds – the ratio of debt-to-GDP past which an increase in debt has a negative effect on the GDP growth rate – when compared to the existing literature. The thresholds obtained averaged 105% for fixed effects models, and 118% for instrumental variables models, which are considerably high when compared to similar literature. Therefore, some empirical evidence was obtained suggesting that the increase in debt that came to be during the European sovereign debt crisis moved the debt turning point thresholds, rather than adhered to them. This may be a particular quirk of the panel observed, or may represent the effects of a new underlying framework, such as the relatively newer European institutions, that are not as prominent when longer periods are used.

The increase in the thresholds obtained was accompanied by a widening of the confidence intervals associated with those values. Due to this, concrete policy implications are now much harder to draw from these thresholds due to the uncertainty surrounding the exact debt ratios to avoid. While the results obtained support the Maastricht limit of 60% as safe, falling below the lower band of nearly all the confidence intervals computed, little evidence was found that slightly higher debt-to-GDP ratios (up to around 90 to 100%) cause growth to slow down. One

less discussed point is that, in the context of this analysis, the turning point is, by definition, the debt-to-GDP ratio that maximizes growth, which means that lower ratios would also impact growth negatively in the same manner higher ratios do.

The growth rate of the debt-to-GDP ratio was found to have strong explanatory power when the model was expanded to include it, and the dependent variable was either annual or a 5 year non-overlapping window. The effect associated with an increase in debt growth is strongly nefarious for GDP growth. When considering the estimates obtained for the annual models, a reasonably small change in the debt-to-GDP ratio's growth rate could offset considerable changes in the ratio itself, which is a result with very strong policy implications. For one, the high-debt legacy left by the sovereign debt crisis could have its effect mitigated by reasonably small declines in debt growth. If further research confirms it, changes in the ratio's growth rate may prove a very interesting explanatory variable when exploring the nexus between debt and growth.

Bibliography

Afonso, A. & Alves, J. (2015). The role of government debt in economic growth. *Review of Public Economics*, *215*(4), 9–26.

Afonso, A. & Jalles, J. T. (2013). Growth and productivity: The role of government debt. *International Review of Economics & Finance*, *25*, 384 – 407.

Afonso, A. & Jalles, J. T. (2014). Causality for the government budget and economic growth. *Applied Economics Letters*, *21*(17), 1198–1201.

Aizenman, J., Kletzer, K., & Pinto, B. (2007). Economic growth with constraints on tax revenues and public debt: Implications for fiscal policy and cross-country differences. Working Paper 12750, National Bureau of Economic Research.

Baum, A., Checherita-Westphal, C., & Rother, P. (2013). Debt and growth: New evidence for the euro area. *Journal of International Money and Finance*, *32*, 809–821.

Cecchetti, S., Mohanty, M., & Zampolli, F. (2011). The real effects of debt. BIS Working Paper 352, Bank for International Settlements.

Checherita-Westphal, C. & Rother, P. (2012). The impact of high government debt on economic growth and its channels: An empirical investigation for the euro area. *European Economic Review*, *56*(7), 1392–1405.

Chudik, A., Mohaddes, K., Pesaran, M. H., & Raissi, M. (2017). Is there a debt-threshold effect on output growth? *The Review of Economics and Statistics*, *99*(1), 135–150.

Colin Cameron, A. & Miller, D. L. (2015). A practitioner's guide to cluster-robust inference. *Journal of Human Resources*, *50*(2), 317–372.

Diamond, P. A. (1965). National debt in a neoclassical growth model. *The American Economic Review*, *55*(5), 1126–1150.

Ferreira, C. (2014). Debt and economic growth in the european union: what causes what? Working Papers Department of Economics 2014/08, ISEG - Lisbon School of Economics and Management, Department of Economics, Universidade de Lisboa.

Greiner, A. (2013). Sustainable Public Debt and Economic Growth under Wage Rigidity. *Metroeconomica*, *64*(2), 272–292.

Kourtellos, A., Stengos, T., & Tan, C. M. (2013). The effect of public debt on growth in multiple regimes. *Journal of Macroeconomics*, *38*, 35 – 43.

Panizza, U. & Presbitero, A. F. (2013). Public debt and economic growth in advanced economies: A survey. *Swiss Journal of Economics and Statistics*, *149*(2), 175–204.

Saint-Paul, G. (1992). Technological choice, financial markets and economic development. *European Economic Review*, *36*(4), 763 – 781.

Schclarek, A. (2004). Debt and economic growth in developing and industrial countries. *Lund University Department of Economics Working Paper*, *2005*, 34.

Spilioti, S. & Vamvoukas, G. (2015). The impact of government debt on economic growth: An empirical investigation of the greek market. *The Journal of Economic Asymmetries*, *12*(1), 34–40.

Ward, H. P., Ricci, L. A., & Pattillo, C. A. (2002). External Debt and Growth. IMF Working Papers 02/69, International Monetary Fund.

Woo, J. & Kumar, M. S. (2015). Public debt and growth. *Economica*, *82*(328), 705–739.

Appendices

Appendix A

Data Description

Table A.1: Data Description

Variable	Description	Unit
gdp_cap	Gross domestic product at 2010 reference levels per head of population	10^3€
gdp_gr	Growth rate of gdp_cap	% of GDP/cap
gov_debt	General government consolidated gross debt	% of GDP
gov_debt^2	Square of gov_debt	–
gov_rev_ca	Cyclically adjusted total revenue of general government	% of GDP
gov_cab	Cyclically adjusted net lending or net borrowing of general government	% of GDP
$lgdp\_cap$	Logarithm of gdp_cap	–
pop_g	Growth rate of the population	%
$gfcf\_total$	Gross fixed capital formation at current prices: total	10^6€
$gfcf\_gov$	Gross fixed capital formation at current prices: general government	10^6€
$gfcf\_priv$	Gross fixed capital formation at current prices: private sector	10^6€
$saving\_gov$	Gross saving: general government	% of GDP
$saving\_priv$	Gross saving: private sector	% of GDP
$imports$	Imports of goods and services at 2010 prices	10^6€
$exports$	Exports of goods and services at 2010 prices	10^6€
$openness$	Sum of $imports$ and $exports$, divided by GDP	% of GDP
LT_real_i	Real long-term interest rates	%
gov_debt_gr	Growth rate of gov_debt	%
gov_bal	Net lending or net borrowing: general government	% of GDP
$gov\_primary\_bal$	Net lending or net borrowing excluding interest: general government	% of GDP
$debt\_service$	$gov\_primary\_bal$ minus gov_bal	% of GDP
$debt\_service\_gr$	Growth rate of $debt\_service$	%

All data sourced from the European Commission's AMECO database.

Appendix B

Test and Regression Outputs

B.1 Preliminary Tests

Table B.1: Unit Root Tests on GPD growth *per capita*: Levin-Lin-Chu

Adjusted t	Panels	Periods
-2.8135***	12	25

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.2: Unit Root Tests on GPD growth *per capita*: Im-Pesaran-Shin

Z-t-tilde-bar	Panels	Periods
-6.7377***	12	25

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Both tests firmly reject the hypothesis that all panels contain unit roots.

Table B.3: Wooldridge Test for Autocorrelation in Panel Data

F	Prob > F
78.415	0.0000

The hypothesis that there is no first order autocorrelation is firmly rejected.

Table B.4: Hausman Test for Fixed Effects and Random Effects

	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
gov_debt	.0812022	.0963329	-.0151307	.0214195
gov_debt2	-.0003903	-.0005187	.0001284	.0001261
gov_rev_ca	-.199095	-.0397617	-.1593333	.1015283
gov_cab	.223926	.2235453	.0003807	.0326742
lgdp_cap	-15.69212	-1.7116	-13.98052	1.923688
pop_g	-2.477012	-1.808504	-.6685079	.3506451
gfcf_total	.1854193	-.0157768	.2011961	.0756387
openness	1.534024	2.236724	-.7026997	.9061058
LT_real_i	-.3237658	-.1283963	-.1953695	.0366678

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 204.28
Prob>chi2 = 0.0000
(V_b-V_B is not positive definite)

A p-value of 0.0000 firmly rejects the null hypothesis that a random effects model would be preferred.

B.2 Regression Outputs

Table B.5: Instrumental Variables Models Excluded

	Cumulative 5 Year Non-Overlapping Growth Rate	
	Model 6	Model 7
Instruments	Avg.	Lags(1-5)
Estimator	2SLS	2SLS
gov_debt	-.2042048	.7323353 **
gov_debt^2	.0034256	-.0028621
gov_rev_ca	-.6392572	-.8109325
gov_cab	.3139384	-.7683758
$lgdp\_cap$	-91.71246 **	-57.19237 **
pop_g	-3.787177	-5.337385 **
$saving\_gov$	-.0683741	2.0006
$saving\_priv$	1.297034	.6030209 *
$openness$	8.500714	4.117417
LT_real_i	-2.05108	.2361318
$Country\ Dummies$	14.93528	4.547974
$Year\ Dummies$	2.947673	-5.675796
N	48	48
$R^2 - Adj$	.7392056	.7597244
$rk\ LM$	.0108408	.0034349
$Hansen\ j$	–	.0318115
$Threshold$	29.80611	127.9367

Notes: Estimated coefficients are marked according to significance level – *10%, **5%, ***1%. The dependent variable is a 5 year non-overlapping sum of GDP growth rates. A comprehensive description of each variable can be found in Appendix A.

Table B.6: Fixed Effects Models with a Crisis Years Dummy

	Annual Growth Rate		Cumulative 5 Year Overlapping Growth Rate	
	Model 1	Model 2	Model 3	Model 4
gov_debt	.1248963 ***	.1151481 ***	.5584808 ***	.6507489 **
gov_debt2	-.0006184 ***	-.0006092 ***	-.0027455 ***	-.0025658 ***
gov_rev_ca	-.0022968	.042245	-.8274248	-.8528041
gov_cab	.2106793 ***	.1852265 ***	-.166643	-.7861764 ***
$lgdp\_cap$	-5.460674	-4.549201	-64.20117 **	-75.90861 ***
pop_g	-1.969517 **	-1.79758 *	-2.938267	-4.14432 *
$gfcf\_total$	.0961038	–	–	–
$gfcf\_gov$	–	-.3424112	-1.870243	–
$gfcf\_priv$	–	.044994	.1011784	–
$saving\_gov$	–	–	–	1.936305 **
$saving\_priv$	–	–	–	.5624901 *
$openness$	1.504972	1.548598	7.650795	8.038124
LT_real_i	-.1476701 ***	-.1690243 ***	.0258798	.2353467 *
$crisis$	-1.303728	-1.248661	2.249251	-.8233148
N	267	267	219	219
$Clusters$	12	12	12	12
$R^2 - within$	.659321	.6602253	.8309056	.8628612
$Debt\,Turning\,Point$	100.9907	94.51074	101.71	126.8105

Notes: Estimated coefficients are marked according to significance level – *10%, **5%, ***1%. The dependent variable is the annual real GDP *per capita* growth rate for the first two models, and a 5 year overlapping cumulative growth rate of the same variable for the latter two. The dummy variable $crisis$ takes the value 1 for the 2009-2017 period. The non-overlapping models were omitted due to colinearity caused by the small number of observations.

Table B.7: Fixed Effects Models with Debt Service

	Annual Growth Rate		Cumulative 5 Year Overlapping Growth Rate		Cumulative 5 Year Non-Overlapping Growth Rate	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
gov_debt	.135408 ***	.1319031 ***	.5311398 **	.6392584 **	.2335496	.1752146
gov_debt^2	-.0006772 ***	-.0006925 ***	-.0026282 ***	-.0025288 ***	-.0016771	-.0007146
gov_rev_ca	-.0101562	.0251357	-1.114041 **	-.9704296 *	.4606506	-1.351514
gov_cab	.2203553 ***	.2058767 ***	-.273572	-.8623728 ***	.9156359 **	.0707412
$lgdp\_cap$	-6.931133 *	-6.02652 *	-79.00175 **	-84.15168 ***	31.59476	-24.48691
pop_g	-2.087055 **	-1.910397 *	-3.695732	-4.052879 *	-5.293102	-10.37037 **
$gfcf\_total$	.1598689	–	–	–	–	–
$gfcf\_gov$	–	-.2227944	-1.752025	–	-2.372596	–
$gfcf\_priv$	–	.0790352	.2968127	–	-1.120113	–
$saving\_gov$	–	–	–	1.904621 **	–	2.266921 **
$saving\_priv$	–	–	–	.6290277 *	–	.8451641 **
$openness$	.741029	.9110993	8.592683	7.414961	-.1614392	-2.084147
LT_real_i	-.1213529 **	-.1445183 **	-.0114975	.1964783	-1.288429	-1.504321 *
$debt\_service$	.006518	.0053865	.0511418	.0440656 *	-.044274	.0190029
$debt\_service\_gr$	-.0002961 **	-.0002632 **	.0003575	-.0001196	-.001112 *	-.0013279 *
N	267	267	219	219	60	60
$Clusters$	12	12	12	12	12	12
$R^2 - within$	.6705511	.6691216	.825922	.8599843	.8771679	.9107079
$Debt\ Turning\ Point$	99.97846	95.23025	101.0458	126.3942	69.62731	122.5967

Notes: Estimated coefficients are marked according to significance level – *10%, **5%, ***1%. The dependent variable is the annual real GDP *per capita* growth rate for the first two models, a 5 year overlapping sum of the same variable for the middle models, and a 5 year non-overlapping sum for the final two. A comprehensive description of each variable can be found in Appendix A.