ERASMUS UNIVERSITY ROTTERDAM
Erasmus School of Economics

Bachelor Thesis IBEB

Investigating the impact of government debt on economic growth: An enhanced estimation employing satellite data

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Date final version: 17th of July, 2020

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ABSTRACT:

Using night-lights-data-augmented GDP figures, this thesis is investigating the impact of gross general government debt on GDP growth and the channels through which this effect propagates using various fixed-effects and OLS regressions over the period from 1992 until 2008. In line with existing literature, a non-linear relationship between growth and debt can be ascertained for all 173 countries in the sample, but the effect of debt varies depending on what country groups are considered. Simultaneously, there is evidence that the annual change of the public debt ratio is linearly and negatively associated with GDP growth. Concerning the channel investigation, debt seems to have a negative impact on the growth of Gross Fixed Capital Formation, both aggregate and private, as well as on Total Factor Productivity growth.

INTRODUCTION:

In today's society debt is ubiquitous. This is true when it comes to individuals in an economy, where pressing issues such as crippling student debt and credit cards come to mind, but even more for the public sector, that has seen an unprecedented rise of government debt of about 5% of GDP yearly over the past four decades (Cecchetti et al., 2011). At the time of writing, the SARS-COVID-19 pandemic is in full swing, with massive economic stimulus plans approved by many states around the world, which is exacerbating the already high public debt burden lots of nations have to stomach even more. Not that the debt levels were pleasant to begin with: Especially the sharp surge in government debt as a result of the financial crisis of 2007-08 has led to concerns about the ramifications for the general economy and the financial markets.

Government debt is the accumulation of all prior government budget deficits and is usually created by the issue of government bonds and bills. In case a country has a relatively bad credit rating, direct borrowing from supranational institutions such as the World Bank occurs occasionally. The recent rise of public debt is accompanied by an expansion in the size of governments. Furthermore, the distribution of government debt around the world varies considerably, with developing countries having higher levels of public debt (around 10% of the GDP[1] on average) than advanced economies. The developing economies in the Middle East and in Sub-Saharan Africa have the highest public debt figures, whereas Latin America and South Asia sport intermediate levels and East Asia and Europe the lowest. When comparing countries by

[1] Gross Domestic Product: the monetary value of all finished goods and services produced within a country's borders in a specific time period.

income, one can see that low-income countries generally also have to bear the highest debt burden (Jaimovich & Panizza, 2010).

To resolve any confusion regarding the terminology, a short overview is provided: In the literature, government debt is often categorized as domestic debt and external debt. Domestic public debt is government debt that is issued under domestic legal jurisdiction, while external public debt refers to the external debts of all branches of government as well as private debt that is issued by private domestic agents under foreign jurisdiction (Reinhart & Rogoff, 2010). Hence, external government yields access to external resources, while domestic borrowing is essentially a transfer of resources within a country. External borrowing is linked to debt crises in developing countries, as these countries' central banks cannot print the currency needed to pay off the debt that is often denoted in USD or other "hard" currencies (Panizza, 2008). In this thesis, the term government debt/public debt denotes the gross general government debt, so the gross of domestic and public debt relative to the country's GDP.

A central issue of the discussion are the likely adverse effects of government debt on capital accumulation and productivity, dampening economic growth, which is assumed to work through a variety of channels such as higher long-term interest rates (Gale & Orszag, 2003; Baldacci & Kumar, 2010), higher future distortionary taxes (Barro, 1979; Dotsey, 1994), higher inflation (Barro, 1995; Cochrane, 2010), and capital formation, so private saving and investment (Checherita-Westphal & Rother, 2010). As of now, there are still huge gaps in understanding what the general relationship between economic growth and public debt is and how it comes about. To tackle this issue and to fathom this complex interplay of different factors, this thesis will be guided by the following main research question:

"What is the impact of government debt on economic growth and through what channels does it propagate?"

Generally, the abovementioned main research question is of vital importance for policymakers. If increasing government debt decreases long-run growth, that could imply a trade-off between short-run fiscal stimuli and long-run growth (Panizza & Presbitero, 2014). In particular for less developed economies the relationship is far-reaching, as high indebtedness could be limiting growth and development (Pattillo et al., 2004). Despite the obvious relevance, there is relatively little literature and empirical research that has addressed the topic and with regards to the existing literature, the findings are ambiguous. Some empirical research has suggested that a non-linear relationship between debt and economic growth might be at play (Nguyen et al., 2003; Reinhart and Rogoff, 2010; Poirson et al., 2002) which deserves closer scrutiny and will form the

first empirical part of this thesis. Investigating the mechanisms through which government debt seems to influence the economy and in turn its growth, however, is of almost equal importance to further the comprehension of the topic and give policy makers the tools to extenuate the adverse effects of accumulating public debt. In particular, the debt overhang theory suggests a nontrivial impact of debt on gross fixed capital formation (GFCF), so the value of acquisitions of existing or new fixed assets by the public and private sector less disposals of fixed assets, which is thought to be one of the main channels through which debt affects economic growth. Hence, the second part of this thesis will be concerned with this channel probing. Both empirical parts of this thesis will mainly rely on fixed effects regressions with added time-varying controls and regular OLS for an exploration of how initial government debt levels affect subsequent growth.

This thesis will add to the existing literature by using a unique approach, that features satellite night lights data to enhance existing GDP growth estimates for countries with poor data availability and institutional quality. Furthermore, the panel of 173 countries covering the period from 1992-2008 entails a relatively recent investigation for a very broad set of countries.

In the following theoretical framework, the theoretical background of the topic will be examined, combined with a consideration of existing empirical evidence. The theoretical framework will give rise to several hypotheses, that are presented in order to break the main research question down into smaller bits. Then a description of the dataset and the methodology ensues for firstly establishing a credible relationship between economic growth and government debt and secondly delving into this relationship by means of a channel investigation, before reporting the results for a) the effect of debt on economic growth and b) the GFCF growth, the long-term interest rate as well as the TFP growth channel investigation. Ultimately, the robustness of the results and possible shortcomings of the research are looked into, before ending the thesis with a conclusion.

THEORETICAL FRAMEWORK:

This theoretical framework aims to provide an overview over each sub question of this thesis. Firstly, the theoretical background will be illustrated, before empirical findings will complete the picture existing literature has drawn.

We start off with the general relationship between economic growth and government debt. Here, two important distinctions need to be made: The first one is a distinction between the short- and the long-run. The conventional view entails that debt, so deficit financing, is able to stimulate aggregate demand and output in the short run (assuming the absence of non-Keynesian effects),

which is in line with the well-known Keynesian model. However, looking at the medium to long run, two theories compete with each other: The popular consensus goes that there is a major peril in holding (too much) public debt, as it crowds out capital and reduces output (Elmendorf & Mankiw, 1999), which is again a prediction of the Keynesian model. This belief, however, is contrasted by another theory that has resurfaced during the last 30 years, which is the Ricardian Equivalence theorem. Essentially, this theory attributes no effects at all to public debt. It has its roots in the permanent income/life cycle hypothesis, which leads to the reasoning that government debt implies future tax taxes with a present value of the debt stock. Agents that act rationally will consider this equivalence and carry on as if the debt not existed, extenuating all detrimental effects of debt to the economy (Seater, 1993). After the resurrection of this theory, many articles tried to empirically test its applicability, but the results were inconclusive (Ricciuti, 2003). In recent years, the Keynesian approach is preferred over the Ricardian, also because there is more research covering the mechanisms behind the effect of debt on growth, which are in accordance with Keynesian theory for the long run (Checherita-Westphal & Rother, 2010).

This Keynesian long run theory has its foundations in works by Modigliani, who stated that government debt is a burden for the next generation, even if it is used as a countercyclical measure, leading to a reduced flow of income due to a lower private capital stock (Modigliani, 1961). With this position he made a stand against the prevailing opinion before the Keynesian revolution, that government debt does not have an impact on future generations, no matter the way of financing. He also indicated the rise of long-term interest rates as a consequence of government borrowing but also regarded the possibility of using debt to finance government expenditure that could have a share in the real income of future generations due to public capital formation. Modigliani extended arguments made earlier by Meade (1958), who mainly considered the adverse effects of domestic debt on working and saving incentives in his analysis. The advent of Keynesian economics fueled the debate about government deficit financing and debt build up, as now debt financed, aggregate demand oriented fiscal policy was broadly employed in developed nations (Motley, 1994). Similar arguments were brought forward by Saint-Paul (1992), who concluded from findings of his endogenous growth model, that an increase in public debt reduces the growth rate, harming a future generation. Similarly, Aizenman et al. (2007) conduct an analysis using an endogenous growth model and conclude that "although the flow of public expenditure raises productivity, the government should not borrow to finance it as the resulting increase in publicdebt would lower welfare and the growth rate. "

In line with this theoretical background, the first hypothesis of this thesis is:

H1: "There is a negative causal relationship between government debt and economic growth".

Empirical research on this sub question is ambiguous: There is a growing number of empirical researches revealing that there exists a negative non-linear correlation between economic growth and public debt both in developing as well as in advanced economies (Reinhartt & Rogoff, 2009; Kumar & Woo, 2010), but a negative correlation does not allow for conclusions about causal effects. Other drivers of the link between government debt and economic growth are brought forward for example by Reinhart et al., 2012, who mention that low economic growth is generally favoring a buildup of government debt, raising the important point of simultaneity or reverse causation, which will be addressed in the econometric analysis later on. Moreover, one has to take into account that government debt is typically measured as a ratio of GDP. This automatically leads to a negative correlation between the two variables (Panizza & Prebitero, 2014). A third point of prudence about the negative correlation is the fact that another variable could exert a joint effect on the two variables, as for example a banking crisis could at the same time lead to a growth deceleration and skyrocketing government debt (Reinhart & Rogoff, 2011). The aforementioned conveys an idea about the complexity of the relationship between the two variables and the challenges posed to estimation methods that try to isolate a causal effect of debt on growth.

On the whole, there is a scientific consensus that suggests a negative relationship between public debt and economic growth which is in line with the observed negative correlation, however, this conclusion is challenged by several papers such as Panizza and Presbitero (2014), who found no causal effect employing an instrumental variable approach, implying that the negative correlation between the two variables should not be used to motivate policy decisions.

Now zooming in closer on the general relationship of government debt and growth, yet another important part of the puzzle is the level of government debt, as the theory establishes that the effects of debt vary considerably depending on the existing debt stock and therefore the interest payments.

It is commonly suggested that "reasonable" levels of borrowing by developing economies are adding to capital accumulation and productivity growth and hence to economic growth. Derived from traditional neoclassical models, financial capital mobility, so the ability to lend and borrow, boosts transitional growth. Capital is flowing to where returns are highest, so capital-scarce countries have an incentive to borrow and invest due to the marginal product of capital being relatively large (Pattillo et al., 2002).

Similarly, from a theoretical standpoint, a growth model proposed by Aschauer (2000) embodying a non-linear impact of public capital on economic growth, presumes that government

debt is at least in part used to finance productive public capital, so that an increase in debt would have positive effects up to a certain threshold.

Looking at empirical research, there is indeed a lot of discord about the nature of the relationship: Recently, empirical research has increasingly stressed the possible nonlinearity, however, the assumptions of nonlinearity differ in their extent. Increasing government debt could even have a positive effect on economic growth up to a certain threshold, after which the effect reverses and impairs economic growth, which was found to be probable in a paper investigating the relationship between public debt and growth in the Euro area by Checherita-Westphal and Rother (2010). Moreover, Pattillo et al. (2002) asserted that the average impact of debt becomes negative at about 35-40% of GDP. Also, Kumar and Woo (2010) found evidence that "higher levels of initial debt have a proportionately larger negative effect on subsequent growth", using panel data from developing and advanced economies. Worth noting is a paper by Reinhart and Rogoff (2010), where a panel data set of 44 countries spanning about 200 years is used to determine economic growth and inflation at different levels of government debt. The results suggest a debt threshold of about 90% relative to GDP, after which median growth rates for affected economies are roughly one percent lower than otherwise. The authors find that the difference in average growth rates between highly indebted countries and less indebted countries is 4.2% in advanced economies. However, the study is purely based on correlation and does not provide any hints for a causal effect, nor does it address issues of endogeneity. This paper needs to be regarded with caution as it sparked a huge controversy with several other researchers challenging its methodology and findings (Herndon et al., 2014).

The second sub question of this thesis will hence explore the nature of the relationship between government debt and economic growth. Is it linear or non-linear? In accordance with recently issued research, a second hypothesis is drawn up:

H2: "The relationship between economic growth and government debt exhibits a non-linear relationship, characterized by a debt threshold, before which debt amplifies growth and after which its effect is detrimental to economic growth."

A number of other studies, especially ones that investigated the impact of government debt on economic growth in developing economies, are based on the debt overhang theory. This theory describes a situation where a country's debt service burden has grown so much that a large portion of output needs to be allocated to foreign lenders which consequently curtails incentives to invest in that country (Krugman, 1988). A high debt service burden lowers private capital

formation and leads to an increase of expected future tax rates. Resources, originally allocated to investing, are now depleted by debt servicing. Additionally, quick-yielding projects are preferred to long-term higher-value investments, so that debt overhang which aggravates both policy and investment, hampers economic growth (Clements et al., 2003). The main channel for this mechanism is thought to be capital formation (Pattillo et al., 2003). Hence, in the second part of the empirical section of this thesis, that is concerned with the channel investigation, the following third hypothesis will be tested:

H3: "There is a negative effect of debt on the growth rate of gross fixed capital formation".

Besides the capital formation channel, rising long-term interest rates form another mechanism through which high government debt is presumed to affect economic growth. Theoretically, the neoclassical growth model serves as foundation for this line of thought, however, the economic theory remains inconclusive looking at the relation between the two variables. Depending on diverging assumptions, like whether government deficits reflect changes in government expenditure or a variation in the timing of taxes, different conclusions are drawn (Laubach, 2009). Interest rates are affected by a lot of different variables simultaneously, which leads to an identification problem when addressing the issue from an empirical perspective. Isolating the effect of fiscal policy and filtering out the distortions brought about by business cycles requires advanced simulation methods, where findings from the U.S. and G7[2] countries suggest that a 1% increase in government debt leads to an increase in long-term interest rates in the range from 6 basis points (6 ‰) to 55 basis points, ceteris paribus (Cohen & Garnier, 1991; Elmendorf, 1993). Based on these estimates, a fourth hypothesis is formulated, that will be tested in the channel investigation part of this thesis:

H4: "There is a positive effect of government debt on the growth of long-term interest rates"

When the relationship between debt and growth is discussed, many papers also look into the effect of debt on productivity, a main driver of economic growth. Usually, productivity is proxied by Total Factor Productivity (TFP) growth, that is the growth of the ratio of aggregate outputs to aggregate inputs. Articles employing models of different economies generally come to the conclusion that an expansion of debt leads to a deterioration of TFP (Kaas, 2014; Chalk, 2000).

[2] The Group of Seven (G7) consists of the seven largest IMF-advanced economies: Italy, Canada, France, Germany, United Kingdom, United States, Japan

This is also consistent with theoretical approaches discussed earlier in the theoretical framework, e.g. Saint-Paul (1992). Looking at previous empirical research, different analyses have yielded different results, partly due to the trade-off between debt-financed capital and a possibly lower growth rate harming future generations. Afonso and Jalles (2013) find a positive effect of government debt on TFP growth in an analysis covering 155 developed and developing countries, while Kumar and Woo (2010) find that a 10 percentage-point-increase in the debt ratio relates to a 0.2 percentage point slowdown per year in the productivity per worker. Moreover, Poirson et al. (2002) observe a negative linear effect of debt on TFP growth. In order to elucidate the relationship between productivity and debt in this analysis, an additional hypothesis is formulated that will conclude the channel investigation part of this thesis, guided by findings of theoretical models:

H5: "There is a negative effect of government debt on the growth of total factor productivity (TFP)"

DATA AND METHODOLOGY:

The dataset consists of a panel of 173 countries and has been created using various sources, covering the period from 1992 to 2008.

Economic growth measure data can be very scarce and unreliable, especially when it comes to countries with poor government statistical infrastructure. Recorded GDP figures often differ substantially from reality, which can be due to growth in the informal sector, defective economic integration, and weak statistical infrastructure. This is why this thesis will implement a new approach to mitigate this problem. Henderson et al. (2012) came up with a way of augmenting official income growth measures using satellite data on night lights. Broken down into its basics, the method comprises conducting a fixed effects regression of growth of income (GDP growth) on the growth of night lights, conditioned as average-weighted light intensity in a generalized area. The fitted values from that regression are then assigned weights depending on the quality of available data of the country and combined with the official data on per capita GDP growth derived from the World Development Indicators database. This approach was employed for the dataset used in this thesis, resulting in an augmentation of the observations for 30 flawed data countries; the regression estimates can be found in the Appendix in Table 14. In that way, the quality and availability of data has been improved dramatically. To the dataset created by Henderson et al. (2012) containing the light intensity variables, government debt data derived from Abbas et al. (2010) was added, where the researchers put together a historical public debt database

from numerous sources, issued by the IMF. These main inputs will be supplemented by population data, saving/investment data (GFCF in particular), data on the ratio of trade to GDP, and a proxy for education, which are the average years of secondary schooling for a country in the population older than 15 years, taken from a regularly updated database first presented in Barro & Lee (2000).

The dataset only comprises 5-year intervals, which is why it mainly serves for the second part of establishing a credible relationship between debt and growth, which employs a regression of GDP growth on initial debt levels. Lastly, data on the price level of capital formation taken from the Penn World Table published by the University of Pennsylvania and the University of Groningen is appended.

Generally, for most of the estimations, the countries in the data set are split into two groups: the "good data" countries, and the "flawed data" countries. This differentiation is adopted from Henderson et al. (2012) and the exact grouping can be found in the appendix and is based on the World Bank data quality score, which ranks countries from 0 to 10 with "flawed data" countries being defined as countries with a score in the range of 0-3 and having a low to middle income. The reasoning behind splitting up the data set are as follows: Several studies have found evidence for systematic discrepancies between official data and independent surveys (for instance household surveys) due to misaligned funding incentives and data collection (Sandefur & Glassman, 2015). This leads to observational errors in the data used and might distort results, so that two different estimations are usually employed in the following to account for poor data. Moreover, the "flawed data" country group is solely composed of developing countries with relatively low GDP and GDP per capita, so that results for this group with enhanced GDP growth estimation can convey an idea of what the growth-debt-relationship looks like for less developed nations.

Table 1. Summary statistics.

	whole sample			"flawed data" country sub sample			"good data" country sub sample		
VARIABLES	Obs. (Countries)	Mean	SD	Obs. (Countries)	Mean	SD	Obs. (Countries)	Mean	SD
GDP growth	2766 (170)	4.074	6.393	475 (30)	3.817	5.279	2291 (140)	4.128	6.601
Gvt. Debt-to-GDP ratio	2765 (173)	68.839	59.559	484 (30)	106.718	81.270	2281 (143)	60.801	50.318
Gross Fixed Capital Formation (GFCF)	2513 (157)	23.053	7.971	459 (29)	20.608	9.775	2054 (128)	23.599	7.403
Population growth	2704 (172)	4.42e+05	1.55e+06	480 (30)	4.38e+05	6.25e+05	2224 (142)	4.43e+05	1.68e+06
Nominal GDP per capita, ln	2776 (168)	7.555	1.595	490 (29)	6.034	1.047	2286 (139)	7.881	1.501
Private GFCF	1233 (95)	15.689	7.342	308 (23)	12.655	7.903	925 (72)	16.699	6.858
Public GFCF	1225 (94)	7.292	4.456	307 (23)	7.874	5.188	918 (71)	7.098	4.168
Trade-to-GDP ratio	2616 (163)	81.605	47.352	467 (29)	61.185	36.204	2149 (134)	86.043	48.322
Years of Secondary Schooling	366 (122)	2.601	1.396	48 (16)	0.965	0.625	318 (106)	2.848	1.312
TFP at constant national prices (2011=1)	1673 (101)	0.978	0.207	204 (12)	0.982	0.341	1469 (89)	0.977	0.181
Long-term interest rate	477 (37)	6.259	4.674	0	missing	missing	477 (37)	6.259	4.674

Note. Flawed data countries include: Myanmar, Angola, Nigeria, Sudan, Vietnam, Burkina Faso, Benin, Ghana, Rwanda, Oman, Algeria, Mali, Iran, Islamic Rep., Cameroon, Niger, Sierra Leone, Gambia, The, Liberia, Central African Republic, Mauritania, Swaziland, Lebanon, Madagascar, Eritrea, Guinea-Bissau, Congo, Rep., Haiti, Coôte d'Ivoire, Congo, Dem. Rep. Burundi

As it can be seen from the table above, the two sub-samples used in this thesis are very different from each other. Starting off with the GDP growth rate, a higher mean is observed for the "good data" country sub sample, while the mean of the debt-to-GDP ratio is much lower, approximately being half of the mean debt for the "flawed data" country sub sample. This illustrates the higher debt burden for this sub sample, which might prove helpful in providing explanations for some results of the empirical analysis later on. The structural differences between

the countries in both sub samples stand out when looking at the years of secondary schooling as well as the trade-to-GDP ratio: For both variables, the "good data" country sub sample exhibits a significantly higher mean, the same goes for Total Factor Productivity (TFP). In Table 8 in the Appendix, minimum and maximum observations for all variables used are additionally indicated. What stands out is the maximum GDP growth rate of almost 150% for Equatorial Guinea in 1997, probably associated with the government deciding to attract financial capital and opening up the private sector with substantially decreasing regulation in that year. The maximum debt-to-GDP ratio in the sample amounts to approximately 712% for Guyana in 1992 due to severe governmental mismanagement.

The empirical part of this thesis, as mentioned earlier, consists of two main parts: Firstly, a credible relationship between government debt and economic growth will be determined by means of a) a fixed effects regression of GDP growth on government debt with added time-varying controls with both linear and quadratic specifications and b) a regression of the GDP growth over the whole period considered (1992-2008) on initial debt levels and several controls. Afterwards, the obtained results will be presented.

In the second part, the channel investigation, we will dig into the relationship between GDP growth and government debt and try to elucidate three of the main channels mentioned in the literature through which the effect propagates: the effect of debt on the growth of GFCF, the effect of debt on the change in long-term interest rates, and the effect of debt on the growth of TFP. Also, for this second part, the methodology will be presented first before considering the results.

The Relationship between Government Debt and Economic Growth

There is an ongoing discussion in the literature as to which econometric tool is most suitable for analyzing the impact of government debt on economic growth to find a causal effect, with the most prevalent ones being fixed effects regressions and instrumental variable approaches. Instrumental variables enjoy increasing popularity in recent research, however, the instruments used in existing literature are usually constructed using workarounds and underlie strong assumptions that they usually do not satisfy, such as in Poirson et al. (2002) and Panizza and Presbitero (2014). This is why most papers on the topic rely on a broad range of estimation techniques in order to gauge an effect.

The panel data set used in this thesis is appropriate for fixed effects regressions, so that this technique, seconded by an OLS regression of the whole period GDP growth on initial debt levels plus controls, is deemed the most suitable to perform the main regression estimations. Fixed effects regressions, such as every other method, comes with a series of limitations and assumptions. To be able to estimate a causal effect with this method, endogeneity, so a possible correlation between the independent variable government debt and the error term, needs to be addressed. Endogeneity can generally arise in three forms: omitted variable bias, simultaneity, and measurement error. Fixed effects regressions account for all time-invariant differences between countries, even if they are unobserved. But time-varying factors remain a concern nevertheless, because even after adding time-varying controls, other unobserved time-varying factors driving changes in the independent and dependent variable cannot be ruled out, which renders omitted variable bias a problem for the following estimations. Measurement errors lead only to biased results, if the dependent variable government debt has been measured with reporting or coding errors. This is assumed not to be the case due to the origin of the data from a well-known and curated database (Abbas et al., 2010). A third drawback of this method is simultaneity, which arises when one or more of the independent variables are jointly determined with the dependent variable economic growth, typically through an equilibrium mechanism (University College London: *Endogeneity*, 2008). Simultaneity is a serious problem when it comes to the investigation of economic growth and public debt, since high debt could have an adverse effect on growth while low growth could also in turn promote higher debt (for reasons unrelated to debt) (Kumar & Woo, 2010). Usually it is mitigated by employing instrumental variable approaches, but in this thesis with its fixed effects regressions, the possible presence of simultaneity needs to be kept in mind and will later be acknowledged in the discussion of the results.

Generally, for all regressions in this thesis, heteroskedasticity-consistent standard errors are estimated to account for potentially differing variance of the error term across observation points. Furthermore, in the fixed effects panel regressions, within-country correlation of the residuals has been allowed for by clustering the standard errors.

Starting off with checking the first and second hypothesis, this paper builds on the estimation approaches used by Checherita-Westphal and Rother (2012), from now on referred to as CWR (2012), as well as Kumar and Woo (2010). Central to the estimation is the conditional convergence hypothesis, which relates GDP growth to the level of income per capita, the gross fixed capital formation rate and the population growth rate (Mankiw et al., 1992). Using that approach, several fixed effects regressions will be estimated in both linear as well as quadratic

specifications. The first difference of debt will be used as explanatory variable, too, given the persistency of the debt-to-GDP ratio. All regressions will including time-fixed effects, as testing whether all year dummy coefficients equal zero for the full model leads to a rejection of the null hypothesis ($F(15, 125) = 12.36$ with $p<0.01$), so that time-fixed effects are added to the model, with the basic estimation equation being as follows:

$$(1) \qquad y_{it} = \alpha + \beta_1 \text{debt}_{it} + \beta_2 \text{debt}^2_{it} + \delta \text{GDPcap}_{it} + \theta \text{ pop}_{it} + \eta \text{ gfcf}_{it} + \lambda \text{ trade}_{it} + \varpi_t + \rho_i + \varepsilon_{it}$$

where:

i	denotes the observation
t	denotes the period
y_{it}	denotes the growth rate of real GDP (first difference of logs, augmented with night lights data)
debt_{it}	is the gross government debt as a share of GDP
GDPcap_{it}	is the nominal GDP per capita
gfcf_{it}	is the gross fixed capital formation as a share of GDP
pop_{it}	is the population growth
trade_{it}	is the trade-to-GDP ratio (trade openness)
ρ_i	is the country-fixed effect
ϖ_t	is the time-fixed effect
ε_{it}	is an unobservable error term

Using abovementioned quadratic functional form, a debt threshold/turning point can be estimated following the approach in CWR (2012) which involves equaling the derivative of the functional form above to zero.

To clarify the relationship between economic growth and government debt further and to provide additional evidence for the first hypothesis, a regression of GDP growth over the whole panel (1992-2008) on initial individual debt levels and several controls will be estimated. This regression's purpose is to throw light on subsequent growth, so what role the initial debt-to-GDP ratio plays as well as it is providing a more long-run oriented approach. With this second specification, this thesis follows the methodology of Kumar and Woo (2010) and their "core set"

of economic variables determining subsequent economic growth is adopted. This "core set" is derived from Sala-i-Martin et al. (2004), where the authors examine the explanatory power of numerous possibly growth determining variables using Bayesian Averaging of Classical Estimates (BACE), so essentially weighted average OLS estimates for every combination of variables. The authors find the strongest evidence for a growth determination for school enrollment, the initial level of GDP per capita and the relative price of investment. Taking into account Sala-i-Martin et al.'s (2004) findings, the equation is set up as follows:

$$(2) \qquad y_{t-\tau} = \alpha + \beta_1 \text{debt}_{i\tau} + \beta_2 \text{GDPcap}_{i\tau} + \beta_3 \text{trade}_{i\tau} + \beta_4 \text{sec\_school}_{i\tau} + \varepsilon_{iT}$$

where:

t denotes the year 2008, τ denotes the year 1992, and T denotes the period (1992, 1993, …, 2008)

y	denotes the growth rate of real GDP over the period
debt_τ	is the gross government debt as a share of GDP in period τ
GDPcap_τ	is the nominal GDP per capita in period τ
trade_τ	is the trade-to-GDP ratio (trade openness) in period τ
sec_school_τ	are the average years of secondary schooling for a country in the population older than 15 years in period τ or in 1995, respective to data availability

This OLS regression also involves a tradeoff with regards to endogeneity, with omitted variable bias being the most pressing issue for this estimation technique. However, as pointed out by Kumar and Woo (2010), this regression uses the initial level of government debt to examine the impact on subsequent growth and may thereby avoid simultaneity and reverse causality. The abovementioned OLS regression is also sensitive to outliers and in the dataset used, some countries exhibit abnormally high initial debt levels in 1992, such as Sudan (455% of GDP) and Guyana (712% of GDP).

RESULTS: Government Debt and Economic Growth

First off, hypothesis 1 will be assessed, which states that there is a negative causal relationship between government debt and economic growth. The results reported in Table 11 and Table 12 in the Appendix show regression estimates for specifications without a squared debt term, so that these regressions investigate a linear effect of debt on GDP growth for both sub

samples of "flawed data" and "good data" countries. As one can see, except for the simplest specification, so model 1 for the "good data" country sub sample, no significant results for the debt coefficient were obtained. This outcome was expected with respect to the existing literature, which strongly points into the direction of a non-linear relationship between economic growth and government debt. The specification with debt in first differences (Table 13, Appendix) yields significant coefficients, both for the "good data" sub sample as well as the "flawed data" sub sample. For the "good data" country sub sample, the negative impact on the annual growth rate of a 1 percentage point acceleration in the yearly change of government debt-to-GDP ratio stands at about -0.07 percentage points, while for the "flawed data" country sub sample, this change is approximately -0.03 percentage points on average, ceteris paribus. When interpreting this outcome, a stronger negative effect is observed for the "good data" country sub sample; providing potential evidence for differences in effects across structurally different countries.

Table 4. Fixed effects regression results with yearly GDP growth as the dependent variable and the gross government debt-to-GDP ratio (ordinary and squared) as independent variable, supported by controls, for the "good data" country sub sample. Year dummies are excluded from the table.

VARIABLES	model 1 GDP growth	model 2 GDP growth	model 3 GDP growth	model 4 GDP growth
Debt	-0.03429***	-0.02346***	-0.01801**	-0.01824**
	(0.00853)	(0.00853)	(0.00859)	(0.00867)
Debt squared	0.00007***	0.00005***	0.00004***	0.00004***
	(0.00001)	(0.00002)	(0.00001)	(0.00001)
ln (GDPcap)		10.07110***	8.81454***	8.79310***
		(1.91726)	(1.95331)	(2.01883)
pop. growth		0.00000***	0.00000***	0.00000***
		(0.00000)	(0.00000)	(0.00000)
GFCF			0.13390***	0.13355***
			(0.03131)	(0.03156)
Trade				0.00180
				(0.00983)
Constant	4.19087***	75.68101***	69.18282***	69.12910***
	(0.76922)	(15.49407)	(16.03207)	(16.20069)
Observations	1,786	1,786	1,786	1,786
R-squared	0.09115	0.15895	0.18080	0.18084
Number of countries	126	126	126	126

Robust standard errors in parentheses

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

With hypothesis 1 still in mind, hypothesis 2 will be regarded, as drawing conclusions depends on the outcome of the regressions that include the squared debt term in Table 4. We observe significant results for debt and the squared term of debt in all models for the "good data" country sub sample. A test whether the coefficient of debt and debt squared are jointly significant has been conducted additionally, leading to the rejection of the test's null hypothesis that both coefficients are jointly insignificant ($F(2, 125)$ with $p<0.01$). We can see how the effect of the linear debt term diminishes once more time-varying controls are added, except for the addition of the last control, the trade-to-GDP ratio, which seems to slightly increase the effect size. Interestingly, the linear debt term coefficient is approximately -0.018 ($p<0.05$), while the squared term coefficient amounts to 0.00004 ($p<0.01$). With this specification, the effect size is not constant across the range of debt-to-GDP ratios. Using these estimates, the effect of a one point increase of the debt ratio around the mean of debt of the "good data" sub sample (change in debt from 60.8% to 61.8%) brings about an approximate change of -0.013 points in GDP growth, which is about 0.3% of GDP growth's mean value for the "good data" country sub sample. This work will not provide a structural interpretation of the coefficients of the control variables, as they only serve as blocking back-door paths of the effect of government debt on growth (Pearl, 2009), however, the control coefficients exhibit the expected signs. These findings contrast with CWR (2012), who found the opposite signs for their debt and squared debt coefficients, however, only looking at 27 countries within the European Union (EU), while in this analysis, 126 countries from all over the world are regarded. The interpretation of quadratic specifications always requires plotting the graph of the function that describes the relationship between economic growth and government debt that has been found. For the "good data" countries, the graph takes the shape of a parabola (convex) with its global minimum at a debt-to-GDP ratio of 228%. According to the regression results, debt would henceforth have a negative impact on economic growth up to a debt-to-GDP ratio of 228%, after which more debt would amplify economic growth. This result is unexpected and not in line with what the theory and the empirical literature suggest.

Table 5. Fixed effects regression results with yearly GDP growth as the dependent variable and the gross government debt-to-GDP ratio (ordinary and squared) as independent variable, supported by controls, for the "flawed data" country sub sample. Year dummies are excluded from the table.

VARIABLES	model 1 GDP growth	model 2 GDP growth	model 3 GDP growth	model 4 GDP growth
Debt	0.01428	0.03003*	0.03199**	0.03292**
	(0.01117)	(0.01638)	(0.01481)	(0.01497)
Debt squared	-0.00009***	-0.00011***	-0.00011***	-0.00011***
	(0.00002)	(0.00003)	(0.00003)	(0.00003)
ln (GDPcap)		9.01955**	8.17340*	8.28995*
		(4.06515)	(3.98613)	(4.08225)
pop. growth		0.00001**	0.00001**	0.00001**
		(0.00000)	(0.00000)	(0.00000)
GFCF			0.08966**	0.07613
			(0.03807)	(0.05207)
Trade				0.01815
				(0.03116)
Constant	1.44453	-58.13995**	-54.91914**	-56.47631**
	(1.30387)	(26.78576)	(26.34601)	(26.64928)
Observations	420	420	420	420
R-squared	0.22391	0.31669	0.32732	0.33208
Number of countries	28	28	28	28

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

When looking at the "flawed data" country sub sample, the picture looks inherently different: Significant results were obtained for the coefficient of debt and the coefficient of squared debt, expect for model 1, which has no controls. This time, it can be seen that the addition of control variables increases the coefficient of debt, while the coefficient of squared debt stays constant. A process that makes sense, as, for the case of the natural logarithm of nominal GDP per capita, which is negatively correlated with debt, this variable increases economic growth and therefore leads to a negative bias of the debt coefficient before including nominal GDP per capita as a control. In model 4 with the most control variables, the coefficient of debt is positive with a size of about 0.0329 ($p<0.05$), while the coefficient of the squared debt term is -0.0001 ($p<0.01$). To also give an idea of the effect size, the effect of a one point increase of the debt ratio around the mean of debt of the "flawed data" sub sample (change in debt from 106.7% to 107.7%) brings about an approximate change of 0.0093 points in GDP growth, which is about 0.2% of GDP

growth's mean value for the "flawed data" country sub sample. Also, in this regression, the control variable coefficients exhibit the expected signs. In order to interpret these results as proposed by CWR (2012), the graph of the suggested GDP growth-government debt relationship for the "flawed data" countries is plotted. An inverse parabola is obtained with a maximum at a debt-to GDP ratio of about 147%. This means that, on average for all countries in the sub sample, government debt would become detrimental to economic growth after crossing the threshold of 147% of GDP. This figure is larger than the findings reported by CWR (2012), who identify a turning point roughly between 90% and 100% of GDP. One possible reason for that could be that their study only builds on member countries of the European Union, while this research looks (in this regression) at 26 low-income countries that are all developing economies. Even though the threshold found in this case is relatively high, this result could give an indication that reasonable debt levels might be beneficial for developing economies, as they have a higher initial debt burden. Other research has also concluded higher debt levels might still be appropriate for low-income countries due to it improving monetary policy, enhancing private savings and financial intermediation (Abbas & Christensen, 2010).

Table 6. OLS regression results with whole period GDP growth (1992-2008) as the dependent variable and the initial (1992) gross government debt-to-GDP ratio as independent variable, supported by controls.

VARIABLES	"good data" countries GDP growth (92-08)	"flawed data" countries GDP growth (92-08)
Initial Debt	-0.00082***	0.00108***
	(0.00020)	(0.00017)
Initial GDPcap	-0.00001***	-0.00010***
	(0.00000)	(0.00003)
Price level of Cap. Formation	-0.05656***	0.23195***
	(0.01019)	(0.05995)
Initial Trade	0.00275***	0.00693***
	(0.00026)	(0.00112)
Initial Years of Sec. Schooling	-0.04391***	0.03586
	(0.01492)	(0.02972)
Constant	-0.11814***	-0.82585***
	(0.04398)	(0.06548)
Observations	1,104	221
R-squared	0.16303	0.29122

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

To substantiate a conclusion for hypothesis 1 and 2, the regression of the whole period GDP growth on the initial value of government debt and several controls is now contemplated. The results can be seen in Table 6. For the "flawed data" country sub sample, a significant ($p<0.01$) and positive effect of the initial level of government debt is found. This would translate approximately into a positive change of 0.001 percentage points on average in the 16-year growth rate of GDP from 1992-2008 if the initial debt-to-GDP ratio is increasing by one percentage point, ceteris paribus. The importance of "reasonable" debt levels for developing low- to middle-income economies could be supported with these findings, which however do not allow for a causal interpretation due to omitted variable bias.

Turning to the "good data" country sub sample, the effect of initial debt on 16-year growth rate of GDP is significant ($p<0.01$) and negative, so an opposite result compared to the "flawed data" country sub sample. A one percentage point increase in the debt-to-GDP ratio would lead to an average negative change of 0.0008 percentage points in the 16-year growth rate of GDP, ceteris paribus.

After consideration of the aforementioned results, hypothesis 1, that states that there is a negative causal relationship between economic growth and government debt, is rejected, as the results obtained with the two estimation strategies remain inconclusive. The whole period growth on initial debt regression hints at a negative effect of government debt on subsequent growth, at least for middle- and high-income countries. However, this result needs to be treated with caution and the effect that is found is most likely not causal due to the abovementioned shortcomings of the OLS regression technique. The fixed-effect regressions established that for some countries this, a negative effect of debt on growth might occur after a certain debt-threshold is crossed, but for the "good data" countries in the sample, a generally negative effect is found up to a debt-to-GDP ratio of 228%, which is relatively high and only surpassed by 63 observations in the data set. Moreover, the linear specifications of the fixed effects model suggest a negative relationship, even if all coefficients obtained are insignificant and do not allow for an interpretation. The linear specification using debt in first differences yields significant negative coefficients and could therefore support the first hypothesis. But, considering all results and their ambiguity, hypothesis 1 needs to be rejected. Hypothesis 2, which claimed that the relationship between economic growth and government debt exhibits a non-linear relationship, characterized by a debt threshold, before which debt amplifies growth and after which its effect is detrimental to economic growth, is rejected as well. The first part of the hypothesis seems to hold, as there is indeed evidence for a quadratic relationship, but the findings for the second part of the hypothesis are ambivalent, as in

the "good data" country sub sample, a negative effect of debt up to a threshold is observed, which then turns into a positive one. When only looking at the results for the "flawed data" country sub sample, hypothesis 2 cannot be rejected.

Channel Investigation

Part II of the empirical part of this thesis is the channel investigation, that will explore the relationship between government debt, GFCF, long-term interest rates, and TFP to check hypotheses 3, 4, and 5. For the three channel investigations, fixed effects regressions with time- and country-fixed effects are conducted.

The regressions are aligned with CWR's (2012) channel investigation with the basic regression equation for the all channels being:

$$(3) \qquad \text{channel}_{it} = \alpha + \beta_1 L.\,\text{debt}_{it} + \beta_3 \text{controls}_{it} + \varpi_t + \rho_i + \varepsilon_{it}$$

where

channel_{it}	is the first difference of GFCF (public, private and total), the long-term interest rate and TFP respectively
$L.\,\text{debt}_{it}$	is the first lag of gross government debt as a share of GDP
controls_{it}	denote control variables. In the case of GFCF, the population growth rate, the trade-to-GDP ratio and the lights-augmented real GDP growth rate are added as controls. For the long-term interest rate, the lagged GDP growth rate and the trade-to-GDP ratio are added as controls. Finally, for TFP, the lagged GDP growth rate, the population growth, long-term interest rates and the trade-to-GDP ratio are added as controls.
ρ_i	is the country-fixed effect
ϖ_t	is the time-fixed effect
ε_{it}	is an unobservable error term

This channel investigation, being a fixed effects regression approach, raises the same concerns as (1), with possibly existing endogeneity.

RESULTS: Channel Investigation

Table 7. Fixed effects regression results with yearly GFCF growth as the dependent variable and the gross government debt-to-GDP ratio as independent variable, supported by controls, for the "good data" country sub sample. Year dummies are excluded from the table.

VARIABLES	model 1 GFCF growth	model 2 private GFCF growth	model 3 public GFCF growth
Debt	-0.01095***	-0.01053**	-0.00153
	(0.00413)	(0.00487)	(0.00272)
GDP growth	0.07953	-0.01267	0.06468*
	(0.08774)	(0.09020)	(0.03502)
pop. growth	-0.00000***	0.00000	-0.00000
	(0.00000)	(0.00000)	(0.00000)
Trade	-0.00291	-0.00433	-0.00375
	(0.01090)	(0.01860)	(0.00743)
Constant	0.74966	0.87048	-0.06961
	(0.80253)	(1.38242)	(0.70761)
Observations	1,804	823	817
R-squared	0.03053	0.02639	0.03906
Number of countries	126	71	70

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

To check hypothesis 3, which predicated that there is a negative effect of debt on the growth rate of gross fixed capital formation, the results of the fixed-effects regression are presented in Table 7. A significant ($p<0.1$) and negative effect of government debt on the growth of total gross fixed capital formation is found for the "good data" country sub sample and a very similar effect on the growth of private GFCF, while the regression using public GFCF as dependent variable does not yield significant results. The coefficient of government debt implies that a one percentage point increase in the debt-to-GDP ratio would bring about an approximate average negative change in the growth of GFCF of 0.011 percentage points, ceteris paribus, for both total GFCF growth and private GFCF growth.

For the "flawed data" country subsample, only the regression using public GFCF growth exhibits a significant ($p<0.05$) and negative effect of debt. Table 15 containing the results can be found in the Appendix. A one percentage point increase in the debt-to-GDP ratio would result in a negative 0.014 percentage point change in public GFCF, on average and ceteris paribus, for "flawed data" countries.

Hypothesis 3 therefore cannot be rejected, as the results indicate a negative effect.

In a next step, the fourth hypothesis will be investigated. In order to examine whether there is a positive effect of government debt on the growth of long-term interest rates, fixed-effects regression results are reported in Table 16 (Appendix). The regression was conducted using the whole sample, as data on long-term interest rates is extremely scarce in countries that do not belong to the European Union. As it can be seen, debt has a negative coefficient, however, it remains insignificant with a t-statistic of -0.89. Also, taking the first difference of debt did not produce significant coefficients. CWR (2012) obtain similar results in their study focusing on the EU and were also not able to establish that government debt determines long-term interest rates, which contrasts with the theoretical literature which asserts the long-term interest channel to be of high importance when it comes to how the effect of government debt on economic growth propagates. In line with the obtained results, hypothesis 4 is rejected as the regression does not yield any significant results.

When it comes to the fifth hypothesis that is concerned with the effect of debt on TFP growth, the employed approach on the basis of CWR (2012) does not yield significant results when debt is used, however, a significant coefficient for the first difference of debt was found (Table 17, Appendix). The first difference estimate suggests that a 1 percentage point acceleration in the debt ratio results in a 0.001 percentage point decrease in the TFP growth rate. The number of observations for this regression is however relatively low because of using long-term interest rate as a control. Based on the results of this regression, the fifth hypothesis cannot be rejected as a negative effect of government debt on Total Factor Productivity could be inferred from these estimation results.

DISCUSSION

Dealing with unanticipated results

Some results of this paper have been in line with expectations, while other findings are not compatible with the theoretical literature as well as previous empirical evidence. The most unanticipated findings are the regression results for the "good data" country sub sample trying to establish a causal relationship between government debt and economic growth (Table 4). First off, the result of government debt amplifying economic growth after a debt-to-GDP ratio of 228% is being reached is contrasting strongly to what previous research has revealed, especially when comparing the results to CWR (2012), which has served as a basis for this estimation. Trying to make sense of this contrarious result, some additional regressions with different sub samples of the data were run. For model 4 in Table 4, the coefficients for debt and the squared debt term do not differ significantly from zero when restricting the sample to only advanced economies or only emerging economies, but the signs of the coefficients for the debt and the squared debt term are such that, if the coefficients were significant, the inverse parabola relationship between debt and growth would exists (Table 18, Appendix). Also, conducting the regression with the same sub sample of countries that has been used by CWR (2012) yields insignificant coefficients, both for a linear and quadratic specification (Table 18, Appendix). Yet, the coefficient of the squared debt term is negative, while the coefficient of the normal debt term is positive, which is again in line with the widely accepted nature of the relationship (inverted parabola) and the findings of CWR (2012). Nevertheless, there are some notable differences between the data used by CWR (2012) and the data used in this thesis: CWR (2012) investigated a longer panel, including observations from 1970 until 2011 and used an additional control variable, namely the cyclically adjusted government balance, which was not included in this thesis. The decision was taken due to two reasons, the first one being data scarcity on the second one the fact that this budget balance expresses changes in government debt as well as differences in fiscal policies among countries, which should be captured by our main dependent variable government debt and the country- and time fixed effects. This additional analysis might point into the direction that the observations in the "good data" country sub sample gave rise to the unanticipated parabola-resembling relationship, but this does not at all allow for inferences about the overall effect on middle- to high-income countries.

The channel investigation has provided some evidence for the debt overhang theory, as there seems to exist a negative effect of government debt on the growth of gross capital formation for the "good data" sub sample. Unfortunately, the regressions involving the "flawed data" country sub sample are not significant, so that no inferences can be made about differences in the channel

propagation of debt among low- to middle-income countries in contrast to countries with decent data coverage.

The debt overhang theory is based on a country's obligation to service its debt, which then leads to a slowdown of the gross fixed capital formation rate and in turn economic growth. Research dealing with different ways to finance government debt, for instance the organization of debt, its maturity, currency denomination and issuing practices, is still relatively scarce, but would add a lot to the analysis of the relationship between debt and growth (Wolswijk & De Haan, 2005). Even after considering the propagation channels, as carried out in this thesis, the relationship remains hard to specify and extending the scope of the topic could prove helpful to make for a more thorough analysis.

Econometric challenges

As indicated in the methodology part of this thesis, the employed estimation techniques come with assumptions and limitations that deserve further scrutiny. Looking at the fixed effects (FE) regressions, endogeneity remains a concern, especially simultaneity. The expression "causal effect" has been used up to this point in the results section with utmost caution, as its use would imply that the methods used in this thesis allow for a causal interpretation of the results. In theory, FE regressions can establish causality if endogeneity (in particular simultaneity and omitted time-varying variable bias) is taken care of, but when looking at existing literature about the debt-growth relationship, the model specifications can differ substantially between one published article and another. The effect sizes found in this thesis should provide a good idea of what the actual causal effect is, however, due to the shortcomings discussed in the methodology section, no claim of causality can be made for the results. This also holds for the OLS regression on the whole period growth, as endogeneity concerns are even more pronounced when using that technique.

An additional shortcoming of this thesis is the short time period considered, as night lights data was only available for 1992-2008. And even for the "good data" country sub sample, data scarcity is another important aspect that needs to be mentioned, as the sample size was at times very small, as in the case of the long-term interest rate FE regression.

CONCLUSION

To answer the research question of this thesis, the main findings that have been obtained using augmented GDP growth data are presented in the following: There seems to exist a non-linear effect of government debt on GDP growth which differs among countries and groups of countries. Moreover, there is evidence that higher initial government debt has an adverse effect

on the subsequent economic growth when looking at middle- to high-income countries ("good data" sub sample), but a growth-promoting effect for low- to middle-income countries over the time period considered. The channel investigation has affirmed the negative effect of government debt on gross fixed capital formation growth, overall and in the private sector, as well as on TFP growth.

The implications for policy, assuming that these findings are robust and do not suffer from econometric or theoretical flaws, are manifold. The most striking recommendation is to adopt different government debt accumulation strategies depending on how developed an economy is. Debt overhang seems to be a key issue that needs to be addressed by policy makers, as developing economies might suffer substantial economic growth losses due to their higher initial debt burden, so that fiscal consolidation, despite its unpopularity, seems important to foster future growth. Furthermore, there seems to be a range of government debt levels that yields the best economic growth outcome for low- to middle-income countries: On the one hand, debt overhang threatens economic development when there is too much debt, on the other hand, too little debt can have adverse effects as well, as shown by the whole period growth regression. Reinhart and Rogoff (2010) estimate that below a debt level of 60% of GDP adverse effects on growth materialize in emerging economies.

It should be noted that this thesis has focused on the long time period from 1992 until 2008. Ideally, policy makers should take measures based on the basis of long run economic relationships, but the recent spike in government debt accumulation around the world might justify the implementation of emergency policy responses, since relationships that have been established using data of "normal" economic times might not apply in these situations.

On a final note, it remains questionable whether government debt financing should be at the center of research. Since one of the main characteristics of money is its homogeneity, it is hard to gauge the long-run implications of a high government debt burden as effects might multiply or abate over time, depending on investment decisions and other factors, but most importantly depending on the general economic climate and structural characteristics of the economy. Incurring government debt might not be the point that deserves increasing attention, it is much more the question of what do to with this financial capital in order to make full use of it.

REFERENCES

Abbas, S. A., & Christensen, J. E. (2010). The role of domestic debt markets in economic growth: An empirical investigation for low-income countries and emerging markets. *IMF Staff Papers*, *57*(1), 209-255.

Abbas, S. M., Belhocine, N., ElGanainy, A. A., & Horton, M. (2010). A historical public debt database. *IMF working papers*, 1-26.

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

Aschauer, D. A. (2000). Public capital and economic growth: issues of quantity, finance, and efficiency. *Economic Development and Cultural Change*, *48*(2), 391-406.

Barro, R. J. (1995). *Inflation and economic growth* (No. w5326). National bureau of economic research.

Barro, R., (1979). On the Determinants of the Public Debt. *Journal of Political Economy*, *85*(5), 940–71.

Barro, R. J., & Lee, J. W. (2001). International data on educational attainment: updates and implications. *oxford Economic papers*, *53*(3), 541-563.

Cecchetti, S. G., Mohanty, M. S., & Zampolli, F. (2011). The real effects of debt.

Chalk, N. (2000). The sustainability of bond-financed deficits: An overlapping generations approach. *Journal of Monetary Economics*, *45*, 293–328.

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.

Cochrane, J. H. (2011). Understanding policy in the great recession: Some unpleasant fiscal arithmetic. *European Economic Review*, *55*(1), 2-30.

Cohen, D., & Garnier, O. (1991). The impact of forecasts of budget deficits on interest rates in the United States and other G-7 countries. *Federal Reserve Board.*

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

Dotsey, M. (1994). Some unpleasant supply side arithmetic. *Journal of Monetary Economics*, *33*(3), 507-524.

Elmendorf, D. W. (1993). *Actual budget deficit expectations and interest rates* (No. 1639). Harvard-Institute of Economic Research.

Elmendorf, D. & Mankiw, N. G. (1999). "Government Debt," in J. B. Taylor and M. Woodford (eds.), *Handbook of Macroeconomics*, Vol. 1C, Amsterdam, North- Holland.

Endogeneity. (2008). *Published Manuscript, Environmental Econometrics (GR03),* University College London (UCL), London, United Kingdom.

Feenstra, R. C., Inklaar, R., & Timmer, M. P. (2015). The next generation of the Penn World Table. *American economic review*, *105*(10), 3150-82.

Gale, W. G., & Orszag, P. R. (2003). *The economic effects of long-term fiscal discipline*. Urban Institute.

Henderson, J. V., Storeygard, A., & Weil, D. N. (2012). Measuring economic growth from outer space. *American economic review*, *102*(2), 994-1028.

Herndon, T., Ash, M., & Pollin, R. (2014). Does high public debt consistently stifle economic growth? A critique of Reinhart and Rogoff. *Cambridge journal of economics*, *38*(2), 257-279.

Jaimovich, D., & Panizza, U. (2010). Public debt around the world: a new data set of central government debt. *Applied Economics Letters*, *17*(1), 19-24.

Kaas, L. (2016). Public debt and total factor productivity. *Economic Theory*, *61*(2), 309-333.

Karreman, B., Werner, G., van der Molen, H., Osseweijer, E., Ackermann, M., Schmidt, H., & van der Wal, E. (2017). Academic Writing Skills for Economics and Business Administration. Amsterdam: Boom|Lemma.

Kumar, M. M. S., & Baldacci, M. E. (2010). *Fiscal deficits, public debt, and sovereign bond yields* (No. 10-184). International Monetary Fund.

Kumar, M., & Woo, J. (2010). Public debt and growth. *IMF working papers*, 1-47.

Krugman, P., 1988, "Financing Versus Forgiving a Debt Overhang," *Journal of Development Economics*, Vol. 29, pp. 253–68.

Laubach, T. (2009). New evidence on the interest rate effects of budget deficits and debt. *Journal of the European Economic Association*, *7*(4), 858-885.

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The quarterly journal of economics*, *107*(2), 407-437.

Meade, J. E. (1958). Is the national debt a burden?. *Oxford Economic Papers*, *10*(2), 163-183.

Modigliani, F. (1961). Long-run implications of alternative fiscal policies and the burden of the national debt. *The Economic Journal*, *71*(284), 730-755.

Motley, B. (1994). Ricardo or Keynes: does the government debt affect consumption?. *David Richardo: Critical Assessments: Second Series*, 10.

Nguyen, T. Q., Clements, M. B. J., & Bhattacharya, M. R. (2003). *External debt, public investment, and growth in low-income countries* (No. 3-249). International Monetary Fund.

Panizza, U. (2008). Domestic and external public debt in developing countries. In *United Nations Conference on Trade and Development Discussion Paper* (No. 188)

Panizza, U., & Presbitero, A. F. (2014). Public debt and economic growth: is there a causal effect?. *Journal of Macroeconomics*, *41*, 21-41.

Pearl, J. (2009). Causal inference in statistics: An overview. *Statistics surveys*, *3*, 96-146.

Poirson, M. H., Ricci, M. L. A., & Pattillo, M. C. A. (2002). *External debt and growth* (No. 2-69). International Monetary Fund.

Reinhart, C. M., & Rogoff, K. S. (2009). The aftermath of financial crises. *American Economic Review*, *99*(2), 466-72.

Reinhart, C. M., & Rogoff, K. S. (2010). Growth in a Time of Debt. *American economic review*, *100*(2), 573-78.

Ricciuti, R. (2003). Assessing ricardian equivalence. *Journal of Economic Surveys*, *17*(1), 55-78.

Saint-Paul, G. (1992). Fiscal policy in an endogenous growth model. *The Quarterly Journal of Economics*, *107*(4), 1243-1259.

Sala-i-Martin, X., Doppelhofer, G., & Miller, R. I. (2004). Determinants of long-term growth: A Bayesian averaging of classical estimates (BACE) approach. *American economic review*, 813-835.

Sandefur, J., & Glassman, A. (2015). The political economy of bad data: Evidence from African survey and administrative statistics. *The Journal of Development Studies*, *51*(2), 116-132.

Seater, J. J. (1993). Ricardian equivalence. *Journal of economic literature*, *31*(1), 142-190.

Wolswijk, G., & De Haan, J. (2005). Government debt management in the euro area: recent theoretical developments and changes in practices. *ECB Occasional paper*, (25).

World Bank. (2020). *World Development Indicators*. Retrieved from databank.worldbank.org

APPENDIX

Table 8. Summary statistics for the whole sample used.

VARIABLES	Obs	Mean	SD	Min	Median	Max
GDP growth	2766	4.074	6.393	-48.680	4.110	149.973
Gvt. Debt-to-GDP ratio	2765	68.839	59.559	0.000	56.241	711.940
Gross Fixed Capital Formation (GFCF)	2513	23.053	7.971	-2.424	22.554	64.897
Population growth	2704	4.42e+05	1.55e+06	-7.50e+05	80023.750	1.69e+07
Nominal GDP per capita, ln	2776	7.555	1.595	4.131	7.460	10.936
Private GFCF	1233	15.689	7.342	-4.080	15.652	55.159
Public GFCF	1225	7.292	4.456	-10.344	6.585	39.984
Trade-to-GDP ratio	2616	81.605	47.352	0.183	72.782	437.327
Years of Secondary Schooling	366	2.601	1.396	0.085	2.604	6.868
TFP at constant national prices (2011=1)	1673	0.978	0.207	0.289	0.979	2.200
Long-term interest rate	477	6.259	4.674	1.003	5.400	87.376

Table 9. Summary statistics for the "flawed data" country sub sample.

VARIABLES	Obs	Mean	SD	Min	Median	Max
GDP growth	475	3.817	5.279	-48.680	4.228	42.301
Gvt. Debt-to-GDP ratio	484	106.718	81.270	4.723	92.068	523.382
Gross Fixed Capital Formation (GFCF)	459	20.608	9.775	-2.424	20.622	61.469
Population growth	480	4.38e+05	6.25e+05	-5.10e+05	2.64e+05	3.36e+06
Nominal GDP per capita, ln	490	6.034	1.047	4.131	5.786	9.212
Private GFCF	308	12.655	7.903	-4.080	11.331	55.159
Public GFCF	307	7.874	5.188	0.100	7.308	39.984
Trade-to-GDP ratio	467	61.185	36.204	0.183	51.947	311.354
Years of Secondary Schooling	48	0.965	0.625	0.166	0.869	2.915
TFP at constant national prices (2011=1)	204	0.982	0.341	0.424	0.967	2.200
Long-term interest rate	0	missing	missing	missing	missing	missing

Note. Flawed data countries include: Myanmar, Angola, Nigeria, Sudan, Vietnam, Burkina Faso, Benin, Ghana, Rwanda, Oman, Algeria, Mali, Iran, Islamic Rep., Cameroon, Niger, Sierra Leone, Gambia, The, Liberia, Central African Republic, Mauritania, Swaziland, Lebanon, Madagascar, Eritrea, Guinea-Bissau, Congo, Rep., Haiti, Côte d'Ivoire, Congo, Dem. Rep. Burundi

Table 10. Correlation table for all variables used.

VARIABLES	GDP growth	Debt	GFCF	Pop. growth	ln (GDPcap)	Private GFCF	Public GFCF	Trade	Years of Sec. Schooling	TFP	LT int. rate
GDP growth	1										
Debt	-0.354	1									
GFCF	-0.492	0.2945	1								
Pop. growth	-0.378	-0.073	-0.158	1							
ln (GDPcap)	-0.666	0.5123	0.9228	-0.063	1						
Private GFCF	-0.357	0.1001	0.9038	-0.119	0.8441	1					
Public GFCF	-0.387	0.4735	0.4019	-0.115	0.3492	-0.029	1				
Trade	0.5609	-0.567	-0.773	-0.043	-0.833	-0.651	-0.412	1			
Years of Sec. Schooling	0.1664	0.1529	0.6479	-0.703	0.5207	0.7055	0.0036	-0.328	1		
TFP	-0.812	0.0918	0.4153	0.5845	0.5311	0.4213	0.0685	-0.418	-0.172	1	
LT interest rate	0.8087	-0.274	-0.564	0.071	-0.699	-0.414	-0.431	0.5616	-0.115	0.635	1

Table 11. Fixed effects regression with yearly GDP growth as the dependent variable and the gross government debt-to-GDP ratio as independent variable, supported by controls, for the "good data" country sub sample. Year dummies have been excluded from the table.

VARIABLES	model 1 GDP growth	model 2 GDP growth	model 3 GDP growth	model 4 GDP growth
Debt	-0.00501	-0.00133	-0.00040	-0.00056
	(0.00868)	(0.00686)	(0.00531)	(0.00553)
ln (GDPcap)		10.40758***	9.01301***	8.99612***
		(1.84727)	(1.91817)	(1.98327)
pop. growth		0.00000***	0.00000***	0.00000***
		(0.00000)	(0.00000)	(0.00000)
GFCF			0.14084***	0.14058***
			(0.03041)	(0.03072)
Trade				0.00144
				(0.00997)
Constant	2.94711***	-79.32654***	-71.70221***	-71.66254***
	(0.86044)	(14.90398)	(15.65277)	(15.81158)
Observations	1,786	1,786	1,786	1,786
R-squared	0.07843	0.15192	0.17643	0.17645
Number of countries	126	126	126	126

Robust standard errors in parentheses

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

Table 12. Fixed effects regression with yearly GDP growth as the dependent variable and the gross government debt-to-GDP ratio as independent variable, supported by controls, for the "flawed data" country sub sample. Year dummies have been excluded from the table.

VARIABLES	model 1 GDP growth	model 2 GDP growth	model 3 GDP growth	model 4 GDP growth
Debt	-0.01845**	-0.01025	-0.00969	-0.00958
	(0.00740)	(0.01110)	(0.01130)	(0.01152)
ln(GDPcap)		7.55378*	6.74112*	6.81941*
		(3.85264)	(3.86284)	(3.96770)
pop. growth		0.00001**	0.00001**	0.00001***
		(0.00000)	(0.00000)	(0.00000)
GFCF			0.08139**	0.06939
			(0.03911)	(0.05509)
Trade				0.01591
				(0.03122)
Constant	3.52978**	-46.92328*	-43.65873*	-44.83623*
	(1.28727)	(25.37478)	(25.49781)	(25.77243)
Observations	420	420	420	420
R-squared	0.20264	0.28826	0.29705	0.30072
Number of countries	28	28	28	28

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

Table 13. Fixed effects regression with yearly GDP growth as the dependent variable and the first difference of the gross government debt-to-GDP ratio as independent variable, supported by controls, for the "good data" country sub sample. Year dummies have been excluded from the table.

VARIABLES	"good data" countries GDP growth	"flawed data" countries GDP growth
Debt, 1st difference	-0.07289***	-0.03425**
	(0.01443)	(0.01480)
ln (GDPcap)	8.16971***	7.53125**
	(2.23393)	(3.45251)
pop. growth	0.00000***	0.00001**
	(0.00000)	(0.00000)
GFCF	0.12652***	0.10096*
	(0.03019)	(0.04937)
Trade	0.00938	0.01618
	(0.00983)	(0.03111)
Constant	-64.79847***	-50.82547**
	(17.65809)	(21.35801)
Observations	1,745	411
R-squared	0.21832	0.33623
Number of countries	126	28

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

Table 14. Fixed effects regression of the natural logarithm of the GDP in constant local currency units on the average weighted lights intensity per cell. Year dummies have been excluded from the table.

VARIABLES	lngdpwdilocal
lnlights	0.24476***
	(0.05603)
Constant	25.42874***
	(0.03665)
Observations	2,819
Number of countries	171
R-squared	0.70022

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

Table 15. Fixed effects regression results with yearly GFCF growth as the dependent variable and the gross government debt-to-GDP ratio as independent variable, supported by controls, for the "flawed data" country sub sample. Year dummies are excluded from the table.

VARIABLES	model 1 GFCF growth	model 2 private GFCF growth	model 3 public GFCF growth
Debt	-0.00573	0.00744	-0.01421**
	(0.00750)	(0.00652)	(0.00545)
GDP growth	0.25666***	0.08894*	0.16590***
	(0.05537)	(0.04652)	(0.04429)
pop. growth	-0.00000	0.00000	-0.00000*
	(0.00000)	(0.00000)	(0.00000)
Trade	-0.01161	0.00495	0.00197
	(0.02319)	(0.01190)	(0.01262)
Constant	-0.25768	-2.32987	1.67514*
	(2.16029)	(1.64261)	(0.88792)
Observations	417	272	272
R-squared	0.09333	0.08005	0.11041
Number of countries	28	23	23

Robust standard errors in parentheses

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

Table 16. Fixed effects regression results with long-term interest rate growth as the dependent variable and the gross government debt-to-GDP ratio as independent variable, supported by controls, for the whole sample. Year dummies are excluded from the table.

VARIABLES	LT interest rate growth
Debt	-0.03349
	(0.03698)
GDP growth, 1st lag	0.08420
	(0.06608)
Trade	0.00017
	(0.02150)
Constant	1.24705
	(3.61281)
Observations	426
Number of countries	37
R-squared	0.03501

Robust standard errors in parentheses

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

Table 17. Fixed effects regression results with TFP growth as the dependent variable and the gross government debt-to-GDP ratio as independent variable as well as its first difference, supported by controls, for the whole sample. Year dummies are excluded from the table.

VARIABLES	model 1 TFP growth	model 2 TFP growth
Debt	0.00010	
	(0.00008)	
Debt, 1st difference		-0.00141***
		(0.00037)
GDP growth	-0.00079	-0.00163**
	(0.00069)	(0.00068)
pop. growth	-0.00000	-0.00000*
	(0.00000)	(0.00000)
Trade	-0.00005	-0.00010
	(0.00007)	(0.00009)
ltint	-0.00064***	-0.00033
	(0.00022)	(0.00023)
Constant	0.01220	0.02419***
	(0.00916)	(0.00791)
Observations	427	424
R-squared	0.02503	0.15737
Number of countries	35	35

Robust standard errors in parentheses

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

Table 18. Fixed effects regression results with GDP growth as the dependent variable and the gross government debt-to-GDP ratio as independent variable, supported by controls, for different sub samples. Year dummies are excluded from the table.

	developing economies	advanced economies	CWR sample
VARIABLES	GDP growth	GDP growth	GDP growth
Debt	-0.00704	0.03804	0.01401
	(0.00963)	(0.02429)	(0.05896)
Debt squared	0.00001	-0.00010	0.00007
	(0.00003)	(0.00010)	(0.00029)
ln (GDPcap)	8.57693***	-1.39798	-10.57428
	(1.93651)	(2.77523)	(6.60041)
pop. growth	0.00000***	-0.00000	-0.00000**
	(0.00000)	(0.00000)	(0.00000)
GFCF	0.12400***	0.27807***	0.42078***
	(0.03173)	(0.06748)	(0.09693)
Trade	0.00371	0.04155**	0.03480*
	(0.01754)	(0.01617)	(0.01867)
Constant	-60.33287***	3.72537	89.96533
	(14.02916)	(24.03576)	(63.74474)
Observations	1,726	480	187
R-squared	0.17976	0.39808	0.62781
Number of countries	121	33	12

Robust standard errors in parentheses

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