Magnus Bergslid, Vegard Johnsen and Erik Simengård

An empirical analysis of public debt and economic growth.

How does public debt contribute to economic growth and are there differences among world countries?

Bachelor's thesis in Economics
Supervisor: Jacopo Magnani
May 2024

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Preface

This bachelor´s thesis is written in the final semester of our bachelor's degree in Economics at Norwegian University of Science and Technology. It occupies the entire course encoded SØK2013, "Bachelor Thesis in Economics" and composes of 7,5 ects.

We want to express our gratitude to our supervisor, associate professor Jacopo Magnani and to the teaching assistant Kornelius Mølmann Fuglem for useful discussions and guidance throughout the process of writing this thesis. The writing process has been much appreciated and we have gained useful knowledge which we will bring into later academic publishing.

Abstract

A decade after the European debt crisis, worldwide public debt levels continue to increase. In light of several countries raising their debt ceiling further, we question these policies and aim to find the ideal public debt-to-GDP ratio for a country to achieve the highest possible GDP growth rate. After carrying out an extensive literature review with ideas and methodologies dating back to the 17th century, we use Ordinary Least Square (OLS) with a quadratic term in order to find a quantitative threshold of when public debt turns bad for economic growth. Using World Bank data for nine lagged control variables and 113 countries from 1990 to 2021, this paper aims to contribute to the research field with updated national-level data and differentiate between developing and developed countries. The results estimate a turning point of 121.58% for developing countries and a negative linear relationship for developed countries.

Sammendrag

Et tiår etter den europeiske gjeldskrisen fortsetter verdens offentlige gjeldsnivåer å øke. I lys av at flere land hever gjeldstaket ytterligere, stiller vi spørsmål ved disse politikkene og sikter mot å finne den ideelle offentlig gjeld-til-BNP-ratioen for et land for å oppnå den høyest mulige BNP-vekstraten. Etter å ha gjennomført en omfattende litteraturgjennomgang med ideer og metoder som går tilbake til det 17. århundre, bruker vi minste kvadraters metode (MKM) med et kvadratisk uttrykk for å finne en øvre grense for når offentlig gjeld får en avtagende virkning for økonomisk vekst. Ved å bruke data fra World Bank for ni forsinkede kontrollvariabler og 113 land fra 1990 til 2021, har denne artikkelen som mål å bidra til forskningsfeltet med oppdaterte nasjonale data og skille mellom utviklings- og utviklede land. Resultatene anslår et vendepunkt på 121,58 % for utviklingsland og et negativt lineært forhold for utviklede land.

Contents

1. Introduction

According to the International Monetary Fund, in 2022, global government debt was 92% of global GDP and has been increasing for the last decades (IMF, 2023). The situation is similar in both the global north and south, with no regional exceptions. In June 2023, the world's largest economy, the US, temporarily paused their government debt ceiling to be able to fund the public budgets and repay already accumulated debt (US Department of the Treasury, 2023). Consequently, the debates on debt levels start to develop again, ten years after the European debt crisis.

There are several ways to refer to this sort of debt, some referee government debt, public debt, or national debt. We have decided that in this paper the term "debt" will refer to central government debt, reason being that it is the main variable of interest in the analysis. We will define and describe this variable in further detail in chapter 3.1.2.

Debt has been an important source of fundings for the monarchies in earlier history. In modern times, i.e. in UK after the glorious revolution in 1688, the parliament took more control over the country's finances and the government started borrowing money by using liquor taxes as collateral (Holtfrerich, 2013). During the 17^{th}, 18^{th} and 19^{th} century, wars were more frequent, and they were often debt-financed. After the Second World War, debt has mostly been used to rebuild nations, to increase welfare and to ensure further growth. Ideally, the goal of government debt is to ensure public expenditures and facilitate economic growth and we aim to test if the latter one really works in today's world. Economic growth is widely used as an indicator of how well an economy is, and in broader terms, how society is doing in quantitative and qualitative manners. In political terms, one can argue it should be clear that debt is good for growth, or else politicians would not issue bonds and acquire debt in the first place. In macroeconomic terms, however, the relationship is not that clear and it has been discussed a lot after the financial crisis in 2008 and its subsequent consequences.

In this thesis, we are interested in finding out what kind of relation there is between debt and growth. This question has been studied before. However, to further strengthen the research in this field we would like to contribute with updated data observations and an extensive collection of control variables. We aim to identify findings that can clearly isolate the actual effects of debt on economic growth. The separation of the observations into developing countries and developed countries enables us to say more precisely which effects debt has, depending on the nature of the economy in question. This is useful since there are major differences between the two groups of countries.

Later, we will come back to the discussion of causal inference, but that is not the only interesting potential finding when studying this topic, because whether debt is good or bad in the first place is important for policy implications. Furthermore, any finding of debt's effect on growth will have huge impacts on the financial markets providing the debt, the different nation's budgets, and the welfare within countries. This is why we find it highly applicable and important to raise the following research question:

How does public debt contribute to economic growth and are there differences among world countries?

The structure of the paper we will follow to answer this question starts with a literature review. We will go through theoretical and empirical studies done both historically and in more recent papers to retrieve ideas for variables and develop existing findings. By getting ideas from earlier research on the topics together with economic intuition, we define in part 3 the variables that we find useful to use in a regression analysis and present the descriptive statistics of the variables. In part 4, we will explain the methodology which we will use in the analysis and its assumptions. In part 5, we present the models for developing and developed countries separately. In part 6 we discuss whether the models satisfy the regression assumptions from part 4. In part 7, the results are interpreted, before we discuss the limitation and implications of the models in part 8. In the very end, we conclude.

2. Literature review

The effect of debt on economic growth has been debated for centuries. With the literature review, the goal is to present the different perspectives on debt and what the potential positive and negative sides of debt are on growth rates. We will also elaborate one important topic when assessing public debt, the turning point of debt. We will evaluate whether there exists a threshold on public debt levels that impacts its contribution to economic growth.

2.1 Historical views on public debt

To ensure that we have sufficient historical insight into the earlier papers on similar topics we do a thorough literature review, focusing on collecting knowledge on different methodical approaches, relevant independent variables, and findings. We will review historical theories and empirical theories timed back to the 17th century and up until more recent times. There are several different theories that argue which effect public debts has on economic growth, some conclude positive effects, others conclude that there is negative or no effect, whereas other conclude on a inverse U-shaped relation with a maximum level. (Saungweme & Odhiambo, 2019)

In 2013, Carl-Ludwig Holtfrerich published a comprehensive review of different British and German economists' views on public debt's role in economic growth from the 18th and 19th century (Holtfrerich, 2013). Most of the history in this section is retrieved from his thorough history paper. His findings were that in earlier days, wars where far more frequent in Europe compared to nowadays. Britain, as an illustration, was at war more than 50% of the years between 1688 and the end of the Napoleonic wars. Holtfrerich argues that these wars were generally financed by governments borrowing money. It is therefore important to keep this in mind while we review earlier literature, because the higher war frequency will most likely have affected the British economists' view on public debt at that time. Broadly speaking, the British classical economists were negative to public debt, whereas the Germans a century later were more positive.

Among great economists believing public debt was negative for a nation's economy was Adam Smith (1723 – 1790) and David Hume (1711 – 1776). In "Wealth of Nations" from 1776, Adam Smith wrote that "The progress of the enormous debts which at present oppress, and will in the long-run probably ruin, all the great nations of Europe, has been pretty uniform" (Smith, 1776, p. 579). Even though Smith does not directly speak about growth in the sense of yearly increase in GDP, his clear view is that public debt at a high level will destroy the economy, indeed being very bad for economic growth. Adam Smith's negative view is explained by the fact that repaying the debt is costly, but he also argued that a war would end earlier if it was tax-financed rather than debt-financed since the citizens would feel the devastating situation in a broader manner.

Another well-known British economist active around year 1800 sharing the negative view on public debt was David Ricardo (1772 – 1823). His explanation was that public debt is negative because it will be necessary to repay the debt by raising taxes, which would lead British products to become relatively more expensive, distorting worldwide product allocation (Holtfrerich, 2013, p. 7). Secondly, he believed that low indebtedness meant that a country was favourable for accumulation of private capital, which in turn would lead to growth and welfare. High public debt would have the opposite effect and a high indebted country would be unattractive for private capital. Even before Ricardo and Smith, economists had a negative view on public debt. David Hume wrote in 1752 that "Either the nation must destroy public credit or public credit will destroy the nation" (Churchman, 2001, as referred to in Holtfrerich, 2013, p. 3). This view was supported by the American politician James Madison who wrote in 1790 that "Public debt is a public curse" (Madison, 1790).

For a century, Smith's views were taught at Prussian universities, and they shared the views that public debt was evil. However, things changed in the second half of the 19th century when the Napoleonic Wars had been finished for decades. Carl Dietzel (1829 – 1884), a relatively unknown German economist is seen as a pioneer in the positive view on public debt . His thoughts are mainly explained due by the fact that he believed government-issued bonds allow for public spendings such as infrastructure, institutions and fixed capital stock, in favour of private consumption which is good for economic growth (Holtfrerich, 2013, p. 15). He developed this idea further and thought increased public debt would facilitate private capital because of better institutions, infrastructure. This goes inversely of how the traditional crowding out-theory suggest the opposite, namely that public capital restrain private capital accumulation. We will elaborate further this theory in the next section. Counting on Dietzel, he explained another advantage of government bonds. In periods of excess money among private actors, they can invest in government bonds rather than on savings accounts, which was seen as a more productive placement since the government could further develop spendings in their public goods. Lastly, Dietzel thought that if a government cannot lend, meaning no debt, they are not flexible and would need to save money for years to come where spendings would increase. These government savings yield lower returns than spending them on growth-exhibiting expenditures and was thus seen as a superfluous policy. Holtfrerich writes; “In other words, freedom of public debt is a luxury afforded at a too high price, i.e. at the expense of the general welfare.” (p. 16). A very describing statement of Dietzel’s pioneering positive view on public debt.

The German economist Lorenz Von Stein (1815 – 1890) who taught at the University of Vienna between 1855 and 1885 was also well known during this epoque with his views on debt and other political science related topics. His main positive view on public debt is conditional on whether the debt issued contributes to productivity that yield at least so much that it will cover the debt service, meaning the repayment of the debt (Holtfrerich, 2013, p. 18). This implies that the expense the debt serves, as well as lending rates and repayment strategies, applies when assessing if debt is good or bad for growth.

The third German economists Holtfrerich talks about is Adolph Wagner (1835 – 1917). His positive view on public debt is somewhat similar to von Stein’s, in the way that his opinion differs regarding to what the debt is used to finance. Wagner meant that issuing debt for the sake of building real capital such as infrastructure or for extraordinary expenses like war was accepted, but not for the sake of operating costs (Holtfrerich, 2013, p. 21). These latter ones should be financed exclusively by taxes. When we soon turn to the theories about public debt’s effect on growth, we will continue on Wagner.

So, to conclude the history part, Classical British economists did unexceptionally have a bad view on public debt, whereas German economists started assessing the expenses-side as well and not only the revenue part. This made the German side more positive, but conditional on what the debt was used to.

2.2 Theories on public debt’s effect on growth.

In theory, debt accumulation can give varied effects on GDP growth. In this section of the literature review, we aim to present the theories for both the potential positive and negative implications associated with debt and how it affects GDP growth.

2.2.1 Theories implying a positive relationship.

The first theory of a positive relationship between public debt and economic growth comes from the already mentioned German economist Adolph Wagner who came up with the "Wagner's Law of Increasing Public Expenditure" (Holtfrerich, 2013, p. 20). It is a theory putting pressure at the fact that when the public necessities grow (as a result from urbanization or similar), the need of public expenditures also increases, and part of these expenditures could be financed through debt. Wagner share the same view as von Stein that the fixed capital increasing part of the public expenditures should be financed through debt, whereas operating costs should be financed by taxes.

Another theoretical perspective inducing a positive relationship between public debt and economic growth in the short run is the conventional, Keynesian model (Elmendorf & Mankiw, 1999, p. 1628). It explains the relationship in a qualitative way and grosso modo it says that more debt stimulates the activity in the economy through more consumption which means more growth and hence a positive relationship. What this simple approach do not consider, however, is that there must be an intertemporal balance in government budgets, which we will talk more about when we now turn to theories implying a negative effect of public debt on growth.

2.2.2 Theories implying a negative relationship.

It is crucial to highlight the impact of excessive debt or when debt turns bad. Accumulating too much debt for no good reason can give a series of negative effect. (Caner, Grennes, & Koehler-Geib, 2010)

The crowding out effect is one of the negative effects of debt accumulation. The government will be able to increase in size to a level which will compete with the private sector for limited resources such as skilled labour, capital and credit markets. This effect can drive up costs for the private sector and could lead to a decrease in investments and company growth on the private side, which will lead to a decline in GDP growth for the country. (Shaari, et al., 2023)

Fiscal imbalance is the result of accumulation of too much debt given the future income. If a government build up too much debt the tax burden for future generation will get much higher.

This can affect the future growth of GDP negatively, since higher tax will lead to lower consumption. (Segura-Ubiergo, Simone, Gupta, & Cui, 2009)

Debt overhang is the effect of an organization accumulating so much debt that they are not able to fund future projects since the burden of debt is higher than the expected value of a new project. The phenomenon of debt overhang can result in underinvestment and hinder economic growth. While debt can serve to finance future investments, its efficacy depends on the expectation that future cash flows will exceed debt obligations. (Philippon, 2009)

2.2.3 Theories implying a non-linear relationship.

The "Debt Laffer Curve" is a concept that illustrates the optimal level of debt and its potential turning point. At lower levels, debt can stimulate economic activity and finance investments. However, as debt levels increase, the associated costs, may become prohibitively high, leading to negative effects, as explained in section 2.2.2. The optimal level of debt varies depending on various factors and is likely to differ from one economy to another. (Bhimjee & Leão, 2020)

2.2.4 Theories implying no relationship at all.

Mankiw & Elmendorf (1999, p. 1640) present the Ricardian equivalence theory. This theory was first elaborated by the British economist David Ricardo in the 19th century. As the theory's name indicate, public debt equivalently affects economic growth no matter its level, implying the level of public debt does not play any role in the question of economic growth. In other words, economic growth is neutral to the public debt level. Ricardo argued that if governments reduced tax by issuing loans to hold government expenditures even, people would account for this in their personal budgets and anticipate that governments are forced to levy higher taxes to repay their loans in later years. Households will save the taxes they save and wait until governments increase the taxes in later years. Thus, the economy is neutral to government expenditures financed through taxes or debt.

2.3 Empirical Literature of public debt's effect on growth.

In the empirical section of the review, the objective is to outline the principal papers addressing the relationship between public debt and GDP growth, along with the diverse methodologies employed to examine this effect. A key emphasis of this section will be to highlight the various variables utilized by researchers in constructing their models. Subsequently, we will incorporate some of these variables into the models in this paper.

2.3.1 Empirics implying a positive relationship.

Maghyereh and Omet (2003) study how the external debt in Jordan affects growth in GDP and find a statistical positive relationship up to a threshold level of 53%. After this optimal level of the external debt, the external debt contributes negatively to GDP growth. Interestingly is also their finding that the negative effect when external debt exceeds the threshold is much larger than the positive effect up until the threshold of 53%. This means it is better for economic growth to be slightly below the threshold, rather than slightly above the threshold, if the country cannot be in optimum of 53% external debt. Even if this is a very interesting result when we later begin the study, one must keep in mind that the optimal level of external debt found by Maghyereh and Omet only accounts for one developing country and that it is the optimal level of *external* debt they find, not the total government debt. However, the patterns of debt arguably remain similar, independent of what type of debt one consider.

Erickson and Owusu-Nantwi (2016) use time series data on Ghana in the period of 1970-2013 and find a statistically significant positive long-run relationship between debt and GDP growth. Unlike most of the papers in the literature however, this paper is not concentrated around a turning point and focuses only on the positive relation.

Uzun et al. (2012) is another paper finding the same long-run positive relationship, but the regressor used in this study was external debt-to-GDP per capita. They used data on 19 transition economies, meaning earlier socialist economies who adopted more liberal policies in the aftermath of the fall of the Berlin wall. The authors conclude that these transition countries are situated early in the “Debt Laffer Curve” which we will see more cases on when we now turn to empirical findings of a negative and later non-linear relationship between public debt and economic growth.

2.3.2 Empirics implying a negative relationship.

Elmendorf & Mankiw (1999) did a literature survey on public debt that showcases the long run effect of debt and the potential crowding out effect. In this paper they show that private savings will rise when public savings fall resulting in reduced domestic investment and a smaller domestic capital stock. With less capital the interest rate will raise which will give higher rates of unemployment and less GDP growth. The government will then tax the people to finance budget deficit´s leading to a growth of public sector and a drop in productivity and GDP growth.

Reinhart and Rogoff (2012) use long-dated cross-country data on public debt developed by Reinhart and Rogoff (2009) to study the growth rates when dealing with high public debt (above 90% debt-to-GDP for at least 5 years). The episodes studied suggest that once you reach such high levels of debt, they are likely to be at a high level for well over 10 years (average 23 years). In these cases, real interest rates where at average levels and the results suggest that public debt overhang does indeed slow down the GDP growth rate.

Kumar & Woo (2010) use panel data from the period 1970-2007 to look at the long-term effect of a high level of debt-to-GDP ratio concluding that a 10 percentage point increase in ratio is associated with a slowdown of growth of 0,2 percentage points per year. Key variables used in this paper are GDP, population, investments, and government size. The results in this paper suggest that the effect is smaller in advanced economies.

2.3.3 Empirics implying a non-linear relationship.

Reinhart and Rogoff (2010) did a big study on 44 countries over a period of about 200 years. They used a data set with over 3700 annual observations, exploring the empirical relationship between economic growth and inflation at different levels of debt. They found that when public debt exceeds 90% of GDP, growth rates drop significantly compared to those with lower debt levels. This counts for both advanced countries and emerging countries. Note however, that Herndon et al. (2014) replicated Reinhart and Rogoff and identified significant errors in the study and claims it suffers from selective data exclusion, coding errors and inappropriate weighting of summary statistics.

Minea and Parent (2012) also revisit Reinhart and Rogoff's findings and suggest a more complex relationship. Their goal was to test Reinhard and Rogoffs conclusion with a different data set. Their findings shows that debt levels between 90 and 115% on average are associated with lower economic growth compared to debt levels between 60 and 90%. This corresponds to the findings of Reinhard and Rogoff. Further, they find a critical threshold around 115% debt-to-GDP ratio and above this level the effect changes from negative to positive.

Checherita and Rother (2012) also found that the impact of GDP growth is not uniform across all levels of debt. The data consist of twelve countries in the euro area from 1970 to 2011. Their findings support the fact that it exists a threshold effect, indicating that while moderate levels of debt may have a neutral or slightly positive impact on growth. The study identified this threshold at 90-100%, where additional debt has a negative effect on economic growth.

2.3.4 Empirics implying no clear relationship.

IMF published in 2012 an excessive overview of public debt levels and in their analysis of debt's effect on growth, their conclusion goes as follows:

> […] it highlights that there is no simple relationship between debt and growth. In fact, our subsequent analysis emphasizes that there are many factors that matter for a country's growth and debt performance. Moreover, there is no single threshold for debt ratios that can delineate the "bad" from the "good.". (IMF, 2012, p. 109)

To conclude the literature review, there is no common perception or consensus of how public debt affects growth. However, the literature review gives us economic ideas, motivates variables to include in the analysis and methodological inspiration. In next part, we will present the data which we use in the analysis.

3.0 Data

In this part of the paper, we are going to cover the data set and the variables we decide to use in the models. The choice of variables is a collection of variables used in the different literature we have presented, together with economic intuition. We are going to describe the different variables and explain why they are used in the model. All data is collected from The World Bank open access data bank and downloaded on the 14th of February 2024. The data observations go from 1990 to 2021 and we select all countries available at the World Bank data base. However, as we will come back to in section 3.2.1, there are missing values in the data set. Handling all this, we end up with a data set with observations from 113 countries around the globe. See appendix 1 to discover the frequency of apparition for countries in the transformed data set.

3.1 Introducing the variables

The model is constructed by one dependent variable (GDP growth), one independent variable (Debt-to-GDP) and nine control variables. The control variables are categorised in different groups, one representing macroeconomic factors i.e. openness to trade, public spendings, unemployment, inflation and external debt and one representing social variables i.e. education, the rate of urban population, population growth and political stability.

3.1.1 The dependent variable, growth

The most conventional way to measure economic growth is the change in GDP from one year to another. GDP is the result of a country´s total output and in general, growing GDP is good.

3.1.2 The independent variable, public debt

As the research question suggests, we seek to explain what effect debt has on countries' growth. The natural choice of the independent variable will thus be government debt as a share of GDP. Speaking about the debt as a ratio is more common than denoting it in nominal terms. Since it is a ratio, it can increase in two ways, either by the fact that nominal debt increases or if the denominator, GDP, decreases. To get as much data observations as possible, we will use the central government debt and not total public debt. This means debt issued by local authorities such as municipalities do not appear. The variable has the name "gov_debt_to_GDP" in the analysis. When we further talk about debt, we talk about debt as a ratio of GDP and not in nominal terms.

3.1.3 The different control variables

In this paragraph we will introduce the control variables we will be using in the regression analysis. The reason we use control variables is to isolate the influence of debt on GDP growth from other factors which are correlated with them both. There are control variables that are more important to control for than other, even if, in some manner, everything affects everything. The choice of control variables is a result of what earlier economists have done on the topic, what historical theories suggest and simple economic intuition which we will explain for each variable.

Inflation:

As we saw earlier, a Ricardian way to think of a negative effect of increased debt would be that prices increase in that country, leading to a relative disadvantage in the world market because of lower sales, which worsen the GDP and thus the GDP growth. Inflation is also a key indicator in macroeconomic expectations and decisions. We will therefore include inflation as one of the control variables. Inflation is measured as the annual change in the consumer price index and will be named "inf" in the statistical tables.

Openness:

Openness is the sum of exports and imports as a share of GDP. It shows how open a country is to the world market. The reason this variable is of interest is first because the exportations and importations make the trade balance and hence the external capital or external debt accumulation. We will come back to the latter one. Openness also says something about the competitivity of a country on the world market and hence its productivity and its potential of growth. This means it can be correlated with both the dependent and independent variable, meaning we are interested in isolating its effect. In the analysis this variable is called "open".

Public Expenditures:

Public expenditure is a key notion in the topic because the debt raised by a government is used to finance public expenditures. They are therefore positively correlated in nominal terms. The World Bank's definition for this variable is "Expense in cash payments for operating activities of the government in providing goods and services". The name of this variable will be called "pub_exp_of_GDP" in the analysis.

Unemployment:

We find this variable interesting in the thesis because it is assumed to be negatively correlated with GDP and hence GDP growth over time. This correlation is known as Okun's law. It is measured as the share of the labour force without work, but available for and seeking employment. The way this is measured might slightly differ from country to country. It is called "unemp" in the analysis.

Population Growth:

Regardless of how the population growth effect the economy it is a variable that is interesting for development and GDP growth. World Bank measure it as the exponential rate of the midyear population between two years. They count residents regardless of legal status or citizenship. We will denote this variable "pop_growth".

External debt:

The reason we want to control for the external debt is that it is a measure of openness in the financial market, as well as the currency the debt is denominated in. We call this variable "ex_debt" in the analysis and it is measured as total external debt to Gross National Income (GNI) and includes long-term and short-term debt and both public and private debt. Since it involves private debt, which occupies most of the total debt, it is not comparable to the public debt variable of interest. The value of this variable is primarily to control for degrees of openness in the financial market in different countries.

Urban population:

More advanced economies tend to be more urbanized. This trend began during the industrial revolution in the 18th century and still goes on. Urbanized economies are thus more likely to be more productive and high urbanization rate is expected to be positively correlated with growth. Therefore, it is interesting to control for this variable. We also expect the urbanization levels to be higher in developed countries, as this is a result of development. The indicator is an estimate from the United Nations World Urbanization Prospects as a percentage of the total population. We call this variable "urb_pop" in the analysis.

Government spendings on Education

Public spendings on education is used as a proxy of the human capital level in the country. More educated populations are often more productive and have higher GDP levels. Thus, it is likely to be higher for the developed countries. The variable refers to the operational costs for education as a percentage on GNI, but excludes costs to buildings and equipment. We denote this as "edu_spend" in the analysis.

Political stability

This variable is a measure of perceptions of likelihood for politically motivated violences or instability and goes from 0 to 100. We expect this measure to be positively correlated with the dichotomous developing/developed country, but it is useful to include this variable since it is continuous. We call this variable "pol_stab" in the analysis.

Dichotomic variable for developing/developed country

We are interested in testing if the debt's effect on growth differs across developing and developed countries, so we need a variable that determine whether a country is classified as developing or developed. The world bank classify four categories of how developed countries are based on the GNI per capita compared to a certain threshold. We chose to classify the countries in two groups, either developed or developing and we will use the "convenient" classification as do the World Bank (2009, p. xxi) where developed countries will be those classified as high/ or upper-middle income and developing countries those classified as lower-middle and low-income. See appendix 2 for the threshold levels according to the World Bank for each year since 1990. The notation in the analysis will be "developed", but we will run separate regression models and it will be clearly stated which group of countries we are talking about for each model.

3.2 Descriptive statistics

After gone through the literature, we ended up with the 12 variables we presented above. To get an overview of the variables we will run descriptive statistics and based on that, we will be able to choose the final variables we can use in the regression models. First, we explain which data transforming we did initially, before we present the summary statistics retrieved from Stata and in the end, we discuss the results for each variable.

3.2.1 Initial data transformation

When we downloaded the data from the World Bank, we chose all countries in the world and the 12 variables described above, with the only restrictions that the first year was 1990 and the last year was 2021. Furthermore, we deleted all the rows in which the debt or the growth variable was missing. Since those are the dependent variable and the variable of interest, we obviously need data observations on those, for a row to be of any interest. The summary statistics table below is retrieved from the statistical software Stata 18.0. All the data handling is done in Jupyter Notebook using Python.

Before we show the summary statistics, we delete some outliers as well, to make the later regression more valid. The maximum inflation rate observed is 7481% from Peru in 1990. Without the deletion of such values, the results would be scattered and imprecise. As we will further elaborate in section 6, we delete all outliers and set a maximum inflation value of 113%. The choice behind this threshold is mainly visual. There is no inflation rates between 113% and 162%, hence this is a natural gap between outliers and more normal observations. By doing this, we lose 11 observations, all of them among the developing countries. See appendix 3 for a visual definition of an inflation outlier. No other natural outliers are found among the other variables.

3.2.2 Descriptive statistics

Table 1: Summary statistics – all countries.

Variables	N	mean	sd	min	max	p25	median	p75
gov_debt_to_GDP	1,742	57.43	37.19	-1.171	277.5	31.08	50.04	74.31
pub_exp_of_GDP	1,653	27.42	10.83	3.910	70.53	18.71	26.08	34.16
ex_debt	952	58.80	43.91	3.895	423.3	31.63	51.17	71.16
GDP_growth	1,742	3.181	4.073	-15.14	24.48	1.396	3.428	5.410
inf	1,710	6.548	11.19	-16.86	112.5	1.81	3.61	7.808
pol_stab	1,307	56.43	27.30	1.005	99.53	33.65	59.52	80
pop_growth	1,742	0.974	1.287	-4.708	11.79	0.195	0.891	1.75
open	1,607	90.21	57.63	15.51	437.3	52.82	78.88	112.6
unemp	1,351	8.198	5.272	0.249	35.46	4.385	6.9	10.72
urb_pop	1,742	60.86	22.80	5.416	100	45.23	64.57	78.34
edu_spend	1,720	4.391	1.672	0.485	12.74	3.229	4.244	5.247
developed	1,742	0.640	0.480	0	1	0	1	1

Note: Table 1 reports the summary statistics of the different variables for all countries in the dataset. Data source: World Bank

From the global summary statistics, we see that we have 1742 rows and 1742 observations for debt and growth over 31 years and for 113 countries. 64% of the observations are among developed countries, meaning 36 % or 627 observations are for developing countries. Overall, the numbers of observations are satisfactory for both categories. Noteworthy is the fact that a country can appear in the data set both as a developed and developing country, but indeed not within the same year. Out of 113 countries, 67 of them are classified developing and 79 developed. This happen because a country can surpass the threshold for a developed country (see appendix 2) during the period between 1990 and 2021 and hence be counted in the two definitions in different years.

Table 2: Summary statistics – developing countries.

Variables	N	mean	sd	min	max	p25	median	p75
gov_debt_to_GDP	627	54.03	32.86	0	277.5	31.23	50.31	66.75
pub_exp_of_GDP	571	22.21	9.176	6.773	62.27	15.26	20.55	27.04
ex_debt	585	64.26	51.30	10.84	423.3	32.55	55.68	73.59
GDP_growth	627	3.776	4.280	-15.14	18.36	2.183	4.364	6.232
inf	618	9.990	14.09	-16.86	107.0	3.328	6.243	10.05
pol_stab	405	38.35	24.76	1.005	98.58	18.4	33.65	55.03
pop_growth	627	1.463	1.461	-4.708	11.79	0.675	1.564	2.376
open	550	77.00	35.47	15.51	321.4	49.74	75.88	96.20
unemp	386	7.857	5.396	0.300	35.46	3.6	6.531	11.71
urb_pop	627	43.82	21.57	5.416	96.91	26.50	42.74	59.46
edu_spend	627	3.978	1.836	0.485	10.17	2.7	3.576	5.146
developed	627	0	0	0	0	0	0	0

Note: Table 2 reports the summary statistics of the different variables for the developing countries. Data source: World Bank

Table 3: Summary statistics – developed countries.

Variables	N	mean	sd	min	max	p25	median	p75
gov_debt_to_GDP	1,115	59.35	39.30	-1.171	253.1	30.88	50.03	81.88
pub_exp_of_GDP	1,082	30.17	10.63	3.910	70.53	21.04	29.72	37.27
ex_debt	367	50.10	26.22	3.895	133.0	30.91	43.94	67.43
GDP_growth	1,115	2.846	3.914	-14.84	24.48	1.140	2.906	4.8
inf	1,092	4.600	8.572	-7.114	112.5	1.415	2.767	5.124
pol_stab	902	64.55	24.34	1.415	99.53	48.56	69.14	84.36
pop_growth	1,115	0.700	1.086	-4.257	6.852	0.086	0.601	1.284
open	1,057	97.09	65.26	15.72	437.3	54.21	82.69	123.3
unemp	965	8.335	5.218	0.249	29.88	4.779	7.023	10.29
urb_pop	1,115	70.44	17.21	18.45	100	57.07	73.73	82.37
edu_spend	1,093	4.627	1.521	1.760	12.74	3.608	4.432	5.3
developed	1,115	1	0	1	1	1	1	1

Note: Table 3 reports the summary statistics of the different variables for the developed countries. Data source: World Bank

<u>Growth</u>

The dependent variable, GDP growth, ranges from -15.14% to 24.48%. However, both the minimum and maximum are values for a developed country and the mean and all the quartiles are higher among developing countries. Even if the range is wide, only 14 observations of growth are below –10% and five values of growth are above +15%. This can be seen in the histogram for this variable, presented in appendix 4.

<u>Debt</u>

The variable of interest, debt-to-GDP, also has a wide range, especially in the top quartile. Among the developing countries, the 25% highest values are between 66.75% and 277.5%, whereas the 25% highest values for among developed countries range between 81.88% and 253.1%. The mean is higher among the developed countries, and for both categories the mean is higher than the median, indicating a right-skewed distribution.

Inflation

Inflation is more stable in developed countries. This is indicated by the standard deviations, which is 8.572 for the developed countries and 14.09 for the developing countries. We earlier explained that all initial values above 113% were removed. Those 11 outliers appeared to be a developing country. By removing these, the maximum in this data set is held by a developed country. Both categories include negative values, meaning the country experienced deflation in a year. Both categories have a right-skewed distribution since the mean is higher than the median.

Openness

The openness variable contains some missing values. The number of observations is 1057 for developed countries and 550 for developing countries. When we later begin the regression analysis, models where there are missing values among the control variables will contain fewer numbers of observations, because the rows where one variable contains a missing value will be excluded from the regression analysis. The openness variable will be 0 in an autarky. In trading countries however, it can exceed 100 and even 200%, because importations can exceed a country's GDP, but exports can at maximum be 100% of the GDP. Not surprisingly, all the parameters are higher for developed countries, as they tend to trade more than developing countries.

Public expenditures of GDP

The variable for public expenditure of GDP also contains some missing values. All the measures, except from the minimum, are higher for developed countries, which is expected as developed countries tend to have larger governments. Interestingly, however, is that the minimum is very low, only 3.91% for a developed country. This shows that there is not a strict correlation between government size and level of development, which we will come back to in section 6.3.

Unemployment

For the unemployment variable, there are even more missing values and especially for developing countries, for which we lose 38.4% of the rows because of missing values. However, the number of observations is still sufficient to do OLS regression. The summary statistics reveal considerable similarities between the developed and developing countries for the mean and the quartiles. One could expect higher unemployment rates in the developing countries. However, this number is measures differently in different countries and the informal sector is not included, which can make the rates artificially low for some developing countries.

Population growth

The population growth is, as expected, higher in developing countries, with an average of 1.463% and less than the half in developed countries (0.7%). It ranges from -4.257% to 6.852% in developed countries and from -4.708% to 11.79% in developing countries.

External debt

The variable counting the external debt contains some missing values, shrinking the number of observations. Models including this variable with contain 367 rows for the developed countries and 585 for the developing countries. The mean is higher for developing countries with 64.26% and 50,10% for developed countries. The minimum is much lower for developed countries with 3.895% and 10.84% for developing countries, and for the maximum, there is a stunning 423.3% for the developing countries and “only” 133.00% for the developed countries. Note, however, that the levels are not comparable to the government debt to GDP levels, as they measure different debts (recall section 3.1.3).

Urban population

The urban population variable shows that on average the developed world is more urban than the developing. This was expected as urbanization is normally a feature of development. The average urbanization rate is 70.44% for developed countries and 43.82% for developing countries. The maximum urbanization rate is 100% and corresponds to Singapore, which has a rate of 100% every year. The differences in the summary statistics between the developed and developing countries are aligned with the expectations.

Government spendings on Education

The spendings on education is, as expected, higher among developed countries. The minimum share spent on education among developing countries is only 0.485%, whereas the maximum among developed countries is 12.74%. All the quantiles are higher among developed countries.

Political stability

The political stability is as expected, higher on average in developed countries, with a mean of 64.55 (on a scale from 0-100) whereas the mean among developing countries is 38.35. The minima are, however, very similar with only 1.005 among developing countries and 1.415 among developed countries. The median, however, is more than doubled for developed countries (69.14) than for developing countries (33.65).

4.0 Methodology

To methodically examine the relationship between debt and economic growth, we will employ multiple linear regression (MLR). We have classified countries into two categories: developed or developing. From this, we will conduct eight different regressions. The models consist of the dependent variable, economic growth (y), and various numbers of independent variables (x_i), with debt being the variable of interest. The MLR employs Ordinary Least Square (OLS) to estimate the selected parameters. The general population model can be formulated as follows:

$$(1)\ \ y = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \beta_3 x_{3t} + \cdots + \beta_k x_{kt} + u$$

The parameter β_0 represents the models intercept and indicates the value of y when all independent variables are equal to zero. β_k is the slope of the equation and reflecting the relationship between y and x. More specific, how y changes when x_k changes with one unit. This implies that the equation accounts for the effect of k independent variables on the dependent variable. The term u, known as the error term, represents other factors not included in the model that are affecting the dependent variable, often referred to as unobserved factors. Optimally, this term is equal to zero, indicating that the model perfectly predicts the dependent variable without any unexplained variance. (Wooldridge, 2021, pp. 21,69).

4.1 Ordinary least squares

The variables' coefficients are estimated through Ordinary Least Square (OLS), which allows us to investigate the effect of debt on growth and simultaneously control for other factors. This method produces estimates that minimize the sum of squared residuals providing us with estimates of how the independent variables affect the dependent variable. The residual can be interpreted as the difference between the actual value of one observation and its fitted value. With k independent variables we aim to estimate the β-coefficients, resulting in equation (2), referred to as an OLS equation. This equation is derived from the sample and attempts to estimate the reel population parameter.

$$(2)\ \ \hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x_{1t} + \hat{\beta}_2 x_{2t} + \hat{\beta}_3 x_{3t} + \cdots + \hat{\beta}_k x_{kt}$$

The hats over the β-coefficients in equation (2) are to signify that these are estimates of the true population parameters. Since these are estimates, several assumptions must be fulfilled to obtain estimates that correspond with the population model (Wooldridge, 2021, pp. 70-71).

4.2 OLS assumptions

To be able to use OLS as a method it is important to present the different assumptions that must hold for the coefficients to be the best possible estimates. These assumptions are also critical for the validity of standard errors, test statistics and confidence intervals generated by the MLR.

4.2.1 MLR.1 – Linearity in parameters

Consider equation (1). The first assumption states that the model is linear in parameters. This means that the relationship between the dependent and independent variables is linear. It is possible to have non-linear variables, but the parameter (β_i) needs to be linear (Wooldridge, 2021, p. 80).

4.2.2 MLR.2 – Random sample

This assumption states that the data is a random sample from the population, $\{(x_{i1}, x_{i2}, \dots, x_{ik}, y_i): i = 1, 2, \dots, n\}$. This ensures that the sample accurately reflects the population without systematic or human bias. To get a random sample all observations need to have the same probability of being picked (Wooldridge, 2021, p. 80).

4.2.3 MLR.3 – No perfect multicollinearity

This assumption states that none of the independent variables is constant, and there is no multicollinearity among the independent variables. This implies that each variable should have some variation in its value. Furthermore, none of the independent variables is a perfect linear combination of others, meaning the correlation between two independent variables cannot be 1. This ensures that the model parameters can be uniquely estimated. It's important to note that it can exist degrees of multicollinearity, but not perfect multicollinearity (Wooldridge, 2021, pp. 80-81)

4.2.4 MLR.4 – Zero conditional mean

The assumption states that the expected value of the error term u, given any value of the independent variable is zero, formally expressed as $E(u|x_1, x_2, \ldots, x_k) = 0$. This implies that the error term should not be correlated with the independent variables. This assumption is crucial for ensuring unbiasedness of OLS estimates. Violation of this assumption can occur from several reasons e.g. omitted variable bias and model misspecification. Omitted variable bias arises when a variable that influences the dependent variable and is correlated with the included independent variables is excluded from the model. Model misspecification, such as not including necessary polynomial term, can also result in not fulfilling this assumption. However, given that the error term consists of unobserved factors, we can never know for sure if the average value of this factors is unrelated to the independent variables (Wooldridge, 2021, p. 82).

4.2.5 MLR.5 – Homoskedasticity

This assumption states that the variance of the error term is constant given any value of the independent variables, formally expressed as $Var(u|x_1, \ldots, x_k) = \sigma^2$. If the variance changes with any of the independent variables, then this assumption fails and heteroskedasticity is present. This assumption is important to ensure that the standard errors of the coefficients are estimated accurately. This implies that if the model consists of heteroskedasticity it will affect the statistical inference (Wooldridge, 2021, p. 88)

4.2.6 MLR.6 – Normality

This assumption states that the population error u is independent of the independent variables and have a normal distribution with zero mean and variance, formally expressed as σ^2: $u \sim Normal(0, \sigma^2)$. MLR. 6 is a strong assumption, because stating that the error term is independent of all the independent variables, naturally enforces both MLR.4 and MLR.5. This is because if the error term is truly independent, then the variance does not change with the independent variables, and we have zero conditional mean (Wooldridge, 2021, p. 118).

The assumptions MLR.1 – MLR.5 are often referred to as the Gauss Markov assumptions. Following these assumptions the OLS gives the best possible estimates for the models' parameters, meaning they are the most accurate without biases (Wooldridge, 2021, p. 96). When adding assumption MLR.6, these are called the classical linear model (CLM) assumptions. If these assumptions are fulfilled, it can be showed that the OLS estimator are the estimators where the variance is minimized (Wooldridge, 2021, p. 118).

4.3 Lagged effect

Economically speaking, most of the variables such as debt, unemployment and population growth will not affect the growth the same year. The effect will be delayed over time. To counter for this we use lagged effects. This means that all the independent variables will be in the regression with growth rate the year after. This allows us to capture the time dynamics and temporal dependencies in the relationship between the independent and dependent variables. The methodical way we are capturing this lagged effect is by making the dependent variable growth a lead variable. Equation (3) shows the regression line mathematically:

$$(3)\ y_{t+1} = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \beta_3 x_{3t} + \cdots + \beta_k x_{kt} + u_t$$

Here, y_{t+1} represent the lead of the dependent variable economic growth, indicating how the current year's independent variables will affect the next year's growth. The coefficients measure the impact of the corresponding independent variables on the future value of the dependent variable. The model allows for the analysis of how today's economic conditions influence outcomes in the next period.

Because we are using panel data, the assumption about no serial correlation is important. This assumption states that conditional on *X*, the errors in two different time period are uncorrelated: $Corr(u_t, u_s) = 0$, for all $t \neq s$ (Wooldridge, 2021, p. 342). Violations of this assumption suggest that errors are serially correlated, implying that if, for instance, the debt level is unexpectedly high in one period, it is likely to remain above average in next periods. No serial correlation is important for both precision and unbiasedness in the models. In this thesis we will not conduct any statistical test to detect serial correlation. However, in an eventual presence of serial correlation, using a lagged dependent variable can be used as method to avoid serial correlation (Keele & Kelly, 2006, p. 187). This implies that we get more robust models. Further, we will in this thesis assume that no serial correlation is fulfilled.

4.4 Turning point method

To investigate the potential non-linear relationship between public debt and economic growth, we are going to employ a quadratic model approach, similar to the methodology by Checherita and Rother (2012). This let us test if there exists an optimal level of debt that maximizes economic growth, beyond which the effect of additional debt becomes detrimental.

With the quadratic model approach, we are adding a quadratic term for public debt to the linear relationship. Consider the equation:

$$(4)\ y = \beta_0 + \beta_1 x_t + \beta_2 x_t^2$$

In this case β_0, β_1, β_2 are parameters and x is the variable for the public debt. Mathematically we must derive function (1) and we get that optimal x is:

$$(5)\ x^* = \frac{\beta_1}{-2\beta_2}$$

When $\beta_1 > 0$ and $\beta_2 < 0$, we can find the maximum point of the function where debt starts to give a diminishing marginal effect on economic growth. Opposite, when $\beta_1 < 0$ and $\beta_2 > 0$, the function has a minimum point. This implies that it is the debt-to-GDP ratio that is associated with the lowest growth. (Wooldridge, 2021, pp. 672-673)

4.5 Hypothesis test

When assessing the effect of debt on growth, whether a coefficient can be interpretable at the population level or not is indeed important. We will not run the t-test explicitly but explain the pattern and how the regression analysis tells us whether the coefficient can be interpreted at the population level, or not. The way the regression analysis does so, is to conduct a hypothesis test to find the statistical significance of a coefficient by running a t-test for each estimated β-coefficient in the model. Firstly, a null hypothesis (H_0) and an alternative hypothesis (H_A) is formulated. The null hypothesis describes a statement that there is no statical significance between the dependent and independent variable, while the alternative hypothesis states that it is a statical significance. The t-test will indicate if the null hypothesis can be rejected or not based on a critical value. If the test static is more extreme than the critical value, meaning the p-value is lower than a 5 % level, we can reject the null hypothesis and the alternative hypothesis is accepted, implying that there is an effect of the parameter on the dependent variable (Wooldridge, 2021, pp. 120-123).

In the Stata regression analysis, the p-value indicates the probability of obtaining a test statistic as extreme as, or more extreme than, the observed value under the null hypothesis. The test statistic is calculated as the estimated β-coefficient divided by its standard error (the number under the estimated β in the table). The test statistic shows how far the estimated β-coefficient deviates from zero, which we expect if the null hypothesis is true. We are going to use a 5% significance level, which means we accept a 5% chance of falsely rejecting the null hypothesis if it is true. In the table, a significance level of 5% is denoted by two stars. This implies that a variable marked with two stars is statistically significant at the 95% level, meaning we would reject the null hypothesis for this variable. Otherwise, variables marked with one star or no stars are not statistically significant at this level, and we would fail to reject the null hypothesis for these variables (Wooldridge, 2021, pp. 130-132).

5.0 Results

In this section, we introduce eight models, four for developing countries and four for developed countries. The first two models are simpler models looking only at the variables of interest. Model (2)-(4) includes the dependent variable as a lead, meaning we look at the growth rate next year, whereas model (1) has the growth rate in the same year as the other variables.

In the results part, the analysis will primarily concentrate on interpreting the outcomes of the models with a significance level above the threshold of 95%. Additionally, we will highlight the statistically significant variables identified across each model to provide a comprehensive overview and changes that comes with adding different control variables.

5.1 Model: developing countries

The first set of models shows the effects for developing countries.

Table 4: The impact of debt on GDP growth for developing countries

VARIABLES	(1) GDP_Growth	(2) Growth_lead	(3) Growth_lead	(4) Growth_lead
gov_debt_to_GDP	-0.0153	0.0137	0.0586***	0.0527
	(0.0124)	(0.0147)	(0.0223)	(0.0463)
Debt2	-1.63e-06	-0.000102	-0.000241*	-0.000142
	(6.74e-05)	(8.69e-05)	(0.000133)	(0.000376)
inf			0.0381**	0.0107
			(0.0168)	(0.0350)
open			0.0216*	0.0335**
			(0.0111)	(0.0149)
pub_exp_of_GDP			-0.143***	-0.170**
			(0.0447)	(0.0711)
unemp			-0.0636	-0.0290
			(0.0548)	(0.0714)
ex_debt			-0.0219**	-0.0229**
			(0.00862)	(0.0103)
edu_spend				-0.176
				(0.283)
urb_pop				-0.00350
				(0.0205)
pop_growth				-0.123
				(0.199)
pol_stab				0.00799
				(0.0157)
Constant	4.609***	3.440***	4.821***	5.144***
	(0.471)	(0.529)	(1.097)	(1.806)
Observations	627	538	265	184
R-squared	0.014	0.003	0.100	0.141

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The sample spans from 1990 to 2021. Model (1) uses growth the same year as all other variables while model (2)-(4) uses growth as a lead variable.

The regression models (1) to (4) presented in the table above provide estimates for the coefficients (β_j) along with their standard errors in parentheses. The significance levels are indicated at the bottom of the table, with three stars denoting significance at a 99% level, two stars at a 95% level, and one star at a 90% level.

The R-squared value is highlighted as an essential indicator of model performance. This value measures the proportion of variance in the dependent variable explained by the variance in the independent variables. A value close to 1 suggests a strong predictive ability, indicating the model effectively captures the relationship between the variables. Conversely, a value near 0 implies limited explanatory power. Therefore, the R-squared value serves as a metric for assessing the accuracy and reliability of the model's predictions. In model (4) we get a R-squared value of 14.1% for developing countries.

Model (1) exhibits no significance for the variables which means we fail to reject the null hypothesis. The constant is significant at a 99% confidence level. The result suggests that when the debt variables are equal to zero the GDP growth rate is expected to be 4.609% on average.

Model (2) replicates the first model but employs lead growth instead of growth at the same year. Consequently, all independent variables become lagged, leading to 1990 GDP Growth observations being replaced by 1991 GDP growth observations, and since we have no data on growth for 2022, we lose the variables in 2021 as well. Moreover, if a country misses consecutive observations during the time period, we lose a second row of observation for that country. Due to this issue, model (2) misses 89 observations from model (1). The constant is significant at a 99% significance level and suggests that when debt is zero the GDP growth rate is expected to be 3.440.

Model (3) introduces macroeconomic control variables. This model fails the test for homoscedasticity in section 6.1.5 which gives us some new standard errors and a different model. Because of this, we will instead interpret the results for this model in section 6.1.5 of the paper.

Model (4) incorporates social control variables. Here the variables open, pub_exp_of_GDP and ex_debt are statically significant above the threshold. The analysis shows that with a 1 percentage point increase in these variables, holding other factors constant, the average changes in GDP growth are as follows: Openness increases growth next year by 0.0335 percentage point, public expenditure decreases growth next year by 0.170 percentage point and external debt decreases growth next year by 0.0229 percentage point. The constant is statistically significant at a 99% significance level and suggests that when all independent variables are equal to zero the GDP growth rate is expected to be 5.144% on average.

The only model with the variable of interest significant above the threshold is model (3). Therefore, we will focus exclusively on this model and discontinue further analysis with the others.

5.2 Model: developed countries

The second set of models is the estimated models for the developed countries.

Table 5: The impact of debt in GDP growth for developed countries

VARIABLES	(1) GDP_growth	(2) Growth_lead	(3) Growth_lead	(4) Growth_lead
gov_debt_to_GDP	-0.0188**	-0.00839	-0.0349	-0.0597*
	(0.00835)	(0.00908)	(0.0323)	(0.0354)
Debt2	-1.82e-05	-2.93e-05	5.63e-05	0.000274
	(4.63e-05)	(5.11e-05)	(0.000234)	(0.000268)
inf			0.0191	0.00870
			(0.0262)	(0.0449)
open			-0.00354	-0.000794
			(0.00933)	(0.0123)
pub_exp_of_GDP			0.00749	0.158**
			(0.0423)	(0.0667)
unemp			0.0459	0.0224
			(0.0550)	(0.0676)
ex_debt			-0.000233	-0.0128
			(0.0116)	(0.0142)
edu_spend				-0.831**
				(0.323)
urb_pop				-0.0600**
				(0.0294)
pop_growth				1.023**
				(0.448)
pol_stab				0.00849
				(0.0188)
Constant	4.053***	3.406***	3.600**	7.228***
	(0.310)	(0.332)	(1.471)	(2.629)
Observations	1,115	1,020	237	215
R-squared	0.048	0.018	0.041	0.094

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The sample spans from 1990 to 2021. Model (1) uses growth the same year as all other variables while model (2)-(4) uses growth as a lead variable.

The estimates in Model (1) for developed countries is different from those for developing countries. Here, the debt-to-GDP variable is statistically significant at a 95% significant level. Which indicates that a 1 percentage point increase in government debt is expected to slow down the GDP growth rate by 0.0188 percentage point the same year. The constant is statistically significant at a 99% significance level and suggest that when debt is equal to zero, the associated GDP growth rate the same year is on average 4.053%.

Model (2) incorporates lead growth and shows no significant results for the independent variables. The constant is statistically significant at a 99% significance level and suggests that when debt is zero the GDP growth rate is expected to be 3.406% on average.

Model (3) shows no significant results for the independent variables. The constant is statically significant at a 95% significance level and suggests that when all other variables equal to zero, the next year GDP growth rate is expected to be 3.60% on average.

Model (4), the comprehensive model for developed countries does not have statistical significance for the variable of interest. Some of the control variables have statistical significance above the threshold. The variables *pub_exp_of_GDP*, *edu_spend*, *urban_pop* and *pop_growth* is statically significant above the threshold. The analysis shows that with a 1 percentage point increase in these variables, holding other factors constant, the expected average changes in GDP growth are as follows: public expenditure increases growth next year by 0.158 percentage point, education spending decreases growth next year by 0.831 percentage point, urban population decreases growth next year by 0.060 percentage point and population growth increases growth next year by 1.023 percentage point. The constant is statistically significant at the 99% confidence level, indicating that with all other variables held at zero, the expected GDP growth rate for the next year is 7.228%.

Since *Debt2* is not statistically significant for any of the models for the developed countries we will not discuss this or the potential turning point any further for developed countries. We will instead focus on model (1) for developed countries, since it is the only model where the variable of interest, debt, is statistically significant above the threshold and hence interpretable at the population level. When we now turn to part 6, when we test the MLR assumptions in the regressions just presented, we will base the tests on model (3) for developing countries and model (1) for developed countries.

6.0 Discussion around the MLR assumptions

Achieving a model that perfectly reflects the population is challenging, perhaps not possible. This is because the analyses are based on samples from the populations, leading us to work with expected values rather than certainties. This limitation can be controlled for, through the assumptions presented in section 4.2. In this section we are going to conduct several tests to control the MLR assumptions.

6.1 MLR.1 Linearity in parameters

The linearity in parameters within a model can be assessed through the incorporation of quadratic terms of the predicted parameters to the model and check if these additional terms are statistically significant. If they are, it is likely that a non-linear relationship holds, which indicates that the linearity assumption is violated. This test is called a Ramsey RESET test (Wooldridge, 2021, p. 297)

For the sample with developing countries using model (3):

$$F(3, 256) = 1.70$$
$$Prob > F = 0.1674$$

For the sample with developed countries using model (1):

$$F(3, 1109) = 2.83$$
$$Prob > F = 0.0374$$

The results for the sample with developing countries do not meet the threshold of 5% (0.05) to reject the null hypothesis, which means we fail to reject. However, the analysis for developed countries fails the test, suggesting potential non-linearity or the presence of omitted variables in the model. The RESET test does not exclusively look at linearity; rather, it evaluates whether the linearity or form of the model is correct. While the results may indicate that this assumption is intact, it does not provide full certainty for a correctly specified model.

6.2 MLR.2 Random sampling

To satisfy this assumption, each observation, or the probability of having an observation for each country should be uniform. Under this premise, one would expect a higher number of observations from the global south compared to what we have in the data set (consider the map in appendix 1). This suggests a violation of the MLR.2 assumption, indicating that the data set does not uniformly represent all relevant geographical areas and thus do not represent the entire population, namely all world countries. Moreover, in a panel data set as we use, the observations are not randomly assigned since they depend on the year, this also violates the random sampling assumption. Lastly, as mentioned in section 3.2.1, we delete values that are missing for the variable of interest and the dependent variable. The missing values are not random, and it creates a bias in disfavour of countries with measurement issues. These three arguments deny the fact that we have a complete random sample. We will talk further about this in section 8.1.

6.3 MLR.3 No perfect multicollinearity

A common way to control for this assumption is to test for the variance inflation factor (VIF). VIF measures how much the variance of an independent variable is affected by the variance of another independent variable. A common threshold value for VIF is 10, which is equivalent to a correlation of 0.9 (Wooldridge, 2021, p. 92). Together with this, we are also going to use correlation matrices.

Table 6: Correlation matrix for developing countries model (3).

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) growth_lead	1.000							
(2) gov_debt_to_GDP	0.060	1.000						
(3) debt_sq	0.037	0.909	1.000					
(4) inf	0.089	0.127	0.196	1.000				
(5) open	-0.061	0.119	0.130	-0.059	1.000			
(6) pub_exp_of_GDP	-0.214	0.091	0.059	0.112	0.518	1.000		
(7) unemp	-0.102	0.366	0.316	0.093	0.103	0.383	1.000	
(8) ex_debt	-0.108	0.477	0.399	0.041	0.404	0.256	0.107	1.000

Note: This matrix displays the correlation between the variables for developing countries model (3). Each cell represents the correlation coefficient between the row variable and the column variable, ranging from -1 (perfect negative correlation) to +1 (perfect positive correlation).

In the correlation matrix from the model with developing countries, we observe that the correlation between $debt$ and $debt^2$ is 0.909. The high correlation is expected, because $debt^2$ is a direct mathematical transformation of $debt$. The square of any variable should be highly correlated with the variable itself. It indicates that when $debt$ increases, $debt^2$ naturally increases in a quadratic manner. Because of this, it does not imply any violation of MLR.3. Furthermore, we see that debt and growth have a correlation of 0.06, which indicates a positive relationship between debt and economic growth next year. As for the other variables, none of the correlations are close to the threshold. From the VIF table for developing countries below, we see that the VIFs are all far below the threshold of 10, except for the naturally high value for $debt$ and $debt^2$.

Table 7: Variance inflation factor for developing countries model (3)

	VIF
gov debt to GDP	6.94
debt_sq	6.24
pub exp of GDP	1.71
ex debt	1.61
open	1.63
unemp	1.42
inf	1.11
Mean VIF	2.95

Note: Table 7 presents the variance inflation factors for the independent variables for developing countries model (3), to assess multicollinearity within the regression. VIF values greater than 10 suggest significant multicollinearity.

The mean variance inflation factor is 2.95 which also strengthens the perception that the sample with developing countries doesn't suffer from multicollinearity. In the case of developed countries, the results presented in part 5 made us more interested in model (1), where there are no control variables. Thus, the multicollinearity does not apply for that model.

6.4 MLR.4 Zero conditional mean

The paper investigates the relationship between public debt and economic growth. Given that economic growth is influenced by numerous factors, isolating the impact of public debt on growth is challenging and indicates that the error term potentially is very big. By using control variables, we aim to minimize this bias and let us predict models that reflects the true relationship between public debt and economic growth. However, as explained we are using model (1) in the discussion on how debt is affecting economic growth for developed countries. This model does not have any of the control variables as the model for developing countries. Because the control variables are supposed to isolate the effect and minimize the bias of the model, the assumption about zero conditional mean is likely not fulfilled in model (1) for developed countries. However, for developing countries we control for macroeconomic factors and can assume the assumption holds.

6.5 MLR.5 Testing for Homoskedasticity

If the models do not fulfil the assumption about homoskedasticity, the variance of the error term changes with any of the independent variables. One way to control for heteroskedasticity is to do a Breuch-Pagan test (Wooldridge, 2021, p. 270). The hypothesis is stated as follows:

H_0: Homoskedasticity (constant variance)
H_1: Heteroskedasticity (not constant variance)

For the sample with developing countries:
$chi2(1) = 12.92$
$Prob > chi2 = 0.0003$

For the sample with developed countries:
$chi2(1) = 0.11$
$Prob > chi2 = 0.7435$

The chi-squared test statistic for developing and developed country is 0 and 0.7435 respectively. The p-value for developed countries is far over critical value, and we can't reject the null hypothesis, which implies that MLR.5 holds. However, the model for developing countries has a p-value close to zero. This indicates that heteroskedasticity is present in the model. This have implications for the validity of the model's statistical inference and the hypothesis test will not be correct.

Violation of this assumption can be considered by using robust standard error. When adjusting the standard errors, we can report statistics that works regardless of the heteroskedasticity present in the model. This method is known as heteroskedasticity-robust procedure because they are valid whether the errors have constant variance (Wooldridge, 2021, p. 263).

6.5.1 Robust model (3) for developing countries.

We are going to present model (3) for developing countries with heteroskedasticity-robust standard errors:

VARIABLES	(3) Growth_lead
gov_debt_to_GDP	0.0586**
	(0.0240)
Debt2	-0.000241**
	(0.000103)
inf	0.0381***
	(0.0133)
open	0.0216**
	(0.0107)
pub_exp_of_GDP	-0.143**
	(0.0589)
unemp	-0.0636
	(0.0587)
ex_debt	-0.0219**
	(0.00848)
Constant	4.821***
	(1.067)
Observations	265
R-squared	0.100

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

Note: This table displays the results from a robust regression model that evaluates the impact of the independent variables on economic growth for developing countries. The model uses heteroskedasticity-robust standard errors to address potential issues of unequal variance across observations.

Since we get new standard errors in this model, we do the interpretation of the results here instead of in section 5.1. The model contains the same variables and is based on the same data set as model (3) in section 5.1. The variable of interest, *debt*, is statistically significant at the 95% level and it is positively affecting the growth next year, whereas the *debt2*-coefficient is negative. This implies a diminishing effect of debt on growth. When the debt increases by 1 percentage point, on average, the growth next year is estimated to increase 0.0586 percentage point, all things equal.

Inflation is statistically significant at the 99% confidence level, indicating that, all else equal, a 1 percentage point increase in inflation is associated with an estimated 0.0381 percentage point increase in GDP growth. Openness is significant at the 95% confidence level, indicating that, all else equal, a 1 percentage point increase in openness is associated with an estimated 0.0216 percentage point increase in GDP growth. Public expenditures shows that a 1 percentage point increase is associated with a 0.143 percentage point decrease in GDP growth, all things equal, and is significant at the 95% level. And lastly, the external debt suggests that a 1 percentage point increase in population growth is expected to decrease GDP growth by 0.0219 percentage point, all things equal. The constant coefficient is 4.821. This means that for a developing country, on average, if all other variables are equal to zero, the growth rate next year is expected to be 4.821%.

The rest of the β-coefficients are not statistically significant above the 95% threshold level and hence, we cannot differentiate the variable's effect from having zero effect on the population level.

To find the turning point we are interested in, we put in the β_1 of 0.0586 and β_2 of -0.000241 into the formula introduced in section 4.4.

$$\frac{\beta_1}{-2 \cdot \beta_2} = \frac{0.0586}{-2 \cdot -0.000241} = 121{,}58\%$$

From the calculations above we see that the maximum level of debt for developing countries according to this model is 121.58%. We will discuss this result in part 7.

6.6 MLR.6 Normality

In section 6.5 we tested both of the samples for heteroskedasticity. We found that the sample with developed countries fulfilled this assumption. The sample for developing countries did not, implying that MLR.6 also is not fulfilled. To get as robust models as possible, we will still test both of the models for the normality assumption. To evaluate the normality of the error terms in the regression models, we will first make a visual inspection of the residuals using histograms. Additionally, we will conduct a statistical test for normality based on skewness and kurtosis, called Jarque-Bera test. The reason why we use the residuals for this testing is because the error term cannot be directly measured. Analysing the residuals allows us to infer the characteristics of these error terms, thereby checking if MLR.6 holds. In appendix 5 and 6 we see the distribution of the residuals for both samples. From this visual presentation, it can look like the residuals in both samples are close to a normal distribution. Earlier we found that the sample with developing countries had heteroskedasticity, and because of this MLR.6 is broken. It is not sufficient to do a visual consideration of this assumption. We will therefore do a statistical test, to further investigate MLR.6. We have the following hypothesis:

H_0: The data follows a normal distribution.
H_1: The data does not follow a normal distribution.

For the sample with developing countries:
$chi2(2) = 59{,}04$
$Prob > chi2 = 0{,}000$

For the sample with developed countries:
$chi2(2) = 98{,}58$
$Prob > chi2 = 0{,}000$

At a 95% significance level and with p-values below 5% (0,05), we reject the null hypothesis that the error term is normally distributed. Both models got a p-value of zero and indicates non-normal distribution of errors. As expected, the sample with developing countries failed this assumption. However, the model for developed countries, which is accepted in MLR5, fails this normality test, indicating the sample error is not normally distributed. In defence of the models, the sample skewness and kurtosis in the Jarque-Bera test are sensitive to extreme observations (Gel & Gastwirth, 2008). Even if we adjusted for the most extreme inflation values, there are degrees of extreme observations or outliers that are included as well, to reflect the data in a best possible manner. Those slight extreme observation will hence affect the Jarque-Bera test.

7.0 Discussion about the results

We have now conducted the models for both the developed countries and adjusted for heteroskedasticity in the model for the developing countries. We saw that the debt's effect on growth differed for the two groups of countries. For the case of developed countries, the debt variable was not statistically significant in the model (2)-(4), thus we cannot distinguish its effect from no effect. From the literature review, this is most congruent with the Ricardian equivalence theory, saying that households would anticipate any increase in the government debt by reducing their consumption to save for the later increase in taxes necessary to repay the debt, and vice versa. For developed countries, the only model where the debt-variable was statistically significant was in model (1). The β_1, implies a negative relationship between debt and growth. This negative relationship is strengthened by the fact that all the β_1-coefficient for model (2)-(4) are estimated to be negative on a sample level, even though they are not statistically significant at the population level. Note also that model (1) does not consider a lag in the debt-variable and that the debt-squared coefficient is close to zero. This means that for developed countries, the data we use cannot determine any turning point for an optimal level of debt. A negative, linear relationship between debt and growth goes in line with the British historical economists, who believed any level of debt is worse than having no debt. It also supports the negative crowding-out theory of increased public debt which we elaborated in the literature review.

When it comes to the developing countries, the debt and its square are statistically significant at the 95% level. The result is close to what Minea and Parent (2012) and Reinhart and Rogoff (2010) found in their studies with an estimated turning point close to 100%. We find an optimal level of 121.58% which is somewhat higher than earlier findings, this might be a result of higher debt ceilings, increased resilience to greater debt levels, and a higher average debt across developing nations over the years. We lack observations of very high debt levels. Only three of all the data observations on debt levels among developing countries are above 180% and 11 are above 150%. This means that we are not qualified to say a lot about the relationship between debt and growth for high debt levels. And the result may not capture the consequence of accumulating too much debt.

For developing countries, we chose to use model (3), which incorporates only economic control variables and do not include social control variables. The model (4), which includes social control variables showed no statistical significance for the variable of interest. This may reflect that the social effects of debt is captured in the economic variables, and thus just bringing noise and higher uncertainty to the estimates of the debt's effect. Disregarding the insufficient statistical significance for the debt-variable in model (4), we see that the estimated coefficient is very similar to the statistically significant coefficient in model (3). This strengthen the perception that the coefficient in model (3) is the correct estimate, as the estimate barely change when involving more control variables. When going from model (1) to model (2), we also see that the β1-coefficient change from being negative to positive, and that it continues to be positive in model (3) and (4). This strengthen the choice of using lagged effects, since the estimates are more correct and similar to the statistically significant estimate when the models are lagged. All these characteristics of the β1-coefficient contributes to the perception that the economic significance of the debt-variable in model (3) seems to be a good estimate of the true coefficient on the population level. Also, the idea that there exists a turning point when debt goes from contributing positively to negatively on growth, is supported by the fact that the *debt2*-variable is negative in all the models for a developing countries, and statistically significant in the interesting model (3).

The results imply that a developing country should strive for a debt level close to 121.58% to have the highest GDP growth rate as possible. Now, over to the research question, which we repeat here:

How does public debt contribute to economic growth and are there differences among world countries?

As the empirical results suggest, indeed there are differences among world countries, based on whether they are developed or developing. For developed countries, we cannot say too much about the isolated effect of debt due to lack of control variables in model (1). The simplest model without control variables suggested that more public debt is bad for economic growth the same year. For developing countries, however, the analysis suggested that acquiring higher levels of debt, up to a certain point, contribute to higher economic growth like most of the theory and other papers highlight. After a debt level of 121.58%, the debt's contribution to economic growth the year after turns bad and decreases for higher levels of debt.

By consequence, the findings suggest that developed countries that will maximize growth should have no debt at all, while developing countries should seek higher debt levels close to 121.58% of GDP. If one compare this turning point to the actual state from the descriptive statistics in section 3.2.2, developing countries should more than double their debt levels on average, which have been at 54.03% during the time period of interest.

8.0 Limitations and implications

The paper contains weaknesses and limitations. Several methodological assumptions were presented in section 4.2, and some of them turned out to be violated as we saw in part 6. We will in this section go through the methodological weaknesses and critics that could be raised of this paper, and present implications from this paper on policies and further research.

8.1 Critic on data

In section 6.2, we said the data observations are not randomly assigned. This motivates further criticism on the data set in general. Even if the World Bank, which is source to all the data, is a reliable source, there can be mistakes and limitations with the initial data set. We had a lot of missing values for the independent variable of debt, which led to fewer observations than optimally. When using secondary data, like we have done, this is expected. However, we checked if data on the debt variable was available elsewhere, which it happened to be. As an example, the two Scandinavian and developed countries Denmark and Norway, both had missing variable since 1994 in the data set from the World Bank. However, OECD have similar data observations for those two countries from 1995 until 2022. Even if there is a slight difference because OECD report general debt, meaning local governments are included, it means OECD also know the central government debt (since it is a part of the general debt). Another example of missing data in the World Bank is Moroccan debt, which IMF have data on for all years in the period of interest, whereas we only get 17 years of observation from the World Bank. If we were able to correct for these differences in data availability, we could have had fewer missing variables, which could increase the precision, the statistical significance, and the internal validity in the regression analysis. That said, using only one data source is a strength because the overall methodology of data acquisition and intra-organizational policies does not fluctuate, reducing the uncertainty of measurement errors between different variables.

In section 3.2.1, we did some initial data transformation from a raw data set, i.e. deleting missing values and extreme outliers. The choice of excluding the inflation rates above 113% was mainly a result of a visual scatter plot showing that there was a gap between those below 113 and those far above 162. See appendix 3 for a visual representation of inflation outliers. Uruguay in 1990 had an inflation rate of 112.5% and Georgia in 1995 had an inflation rate of 162.7%. No inflation rates were found between these values and only 11 units were removed by setting the outlier threshold for inflation at 113%. What is noteworthy is that all 11 units that were removed was a developing country unit. When deleting outliers, the regression results get more precise and appropriate in the sake of getting a trustworthy and stable $\hat{\beta}$-coefficient. However, the results will be slightly undervalued when it comes to the control of inflation rates as they were extremely high for some few observations, which we ended up removing. Removing missing values is a trade-off between econometric precision and robustness, and internal validity. Given the astronomic maximum level of inflation, we believe it was a correct decision to drop these 11 values.

When it comes to the number of observations. We ran four different models for each group of country, with more and more control variables. Due to missing values in different years and countries per variable, the number of observations reduce for each model as each unit in a data set used in a regression analysis must have values for each variable in the regression model. When this number reduces for each model, the comparability of the different regression coefficients between the models vanish as the database is not the same anymore. A way to handle this could of course be to reduce the number of observations in the three first models and have the exact same database as in model (4). However, losing more than 80% of the observations would most likely reduce the precision and the interpretability. Hence, we decided to run the different models with the maximum of observations available.

One could also argue that during the period between 1990 to 2021, there has been macroeconomic happenings and crisis which have affected debt and growth rates in a way that disturbs such analysis of optimal debt level. As a robustness check, we run the model (3) for developing countries without the years 2008, 2009, 2020 and 2021 to avoid the financial crisis and the covid-19 pandemic. The debt coefficient gets a value of 0.482, statistically significant at the 90% level. Recalling from section 6.5 that the coefficient was estimated to be 0.0586 when all years were included. We see that excluding these four crisis years have significant effect on the coefficient, but with lower statistical significance. This indicates that further research should consider such years. That said, these years were indeed part of the history and excluding any year due to its unique circumstances may not be appropriate.

The choice of beginning in 1990 and ending in 2021 was a question of data availability. When we lag all the independent variables, indeed we lose the 2021-observations as well, since we do not have growth rates from 2022. All methodological choices that involve reducing the number of observations is arguably a weakness and yields a trade-off between internal precision and methodological quality. As in most empirical analysis, the data availability is a limitation. That said, we believe we have used the available data in an appropriate manner. This type of macroeconomic data on nation level is also very difficult to access in any other way than using a big, non-governmental organization like we did.

One last criticism of the observation used in the regression analysis, is that there are few observations for each country and whether a country has several data observations was entirely dependent on data availability or missing values. This makes it harder to explain the trend, because the economies each year in the database appears in an inconsistent way.

8.2 Critic on the debt variable

Another, more intuitive criticism is that normally, one care more about the net debt than the debt as the World Bank measures it. Let us again use Norway as an example. They have a giant sovereign fund which makes the country's net debt negative, since the asset they hold through the fund is higher than their debt. Thus, Norway would normally not worry about its debt, even though we find a negative relationship for developed countries. Hence, this is more a technical concern than a pragmatic policy concern. In further national debt studies, we would therefore recommend gathering net debt numbers to be able to say more about the policy implication of debt.

8.3 Normative implications

Talking about policy recommendations, the empirical study in this paper showed an inverse U-shaped relation between debt and growth for developing countries and a negative relationship for developed countries. But for any form of relationship, there are limitations in what this could imply on a more normative level. The dependent variable has been economic growth. Even if growth is important and is widely used as a development indicator, it does not tell us anything about the distribution of the growth, or other welfare indications in a country. For further studies, we would consider using the human development index or other non- or only partly economic indicators. The reason behind this is both because growth *per se* is not a goal, but rather what the economic growth could yield to the citizens. As we saw in the literature review, several historical economists believed the effect of debt on growth depends on what specifically the issued debt is used for. Therefore, we believe further studies should focus more on qualitatively assessing what the debt is used for in the public expenditures more than we have done here.

8.4 Country categorisation

We chose to separate the countries into two categories, developing and developed countries. This categorization is commonly used and is practical in order to get more precise results, avoiding mistakes by being to generalist and to be able to give more appropriate policy implications. However, categorizing in such ways raise a problem of why the threshold is sat where it is, but more importantly, the observations around the threshold become important for the variation in the regression results, even if they are very similar just on the different sides of the threshold. As illustration, let us consider Jordan and Georgia in 2017. The threshold was a level of GNI per capita of USD 3956 that year. Georgia considered a developed country that year had a GNI per capita of 4040 USD, while Jordan had a GNI per capita of 3920 USD and is therefore considered developing. Even if they are counted in different categories, the production per capita is almost even. It turns out the GDP growth in Georgia was twice as high that year compared to the growth in Jordan, whereas the debt was nearly the half. This is a good example of a case where the side of which the country is relative to the threshold will affect the results. This problem is one part of a trade-off between country-specific precision and economic interpretability.

8.5 Lagged effects

We introduced lagged effects in the regression analysis, based on the intuition that it takes time before the effects of debt shows off. The models for developed countries showed no statistical significance when the debt variable was lagged with one year i.e. in model ((2) to (4), however, it is statistically significant at the 5% level when the debt variable was not lagged, i.e. in model (1). For developing countries, the lagged model (3) turned out to be statistically significant. What could be done is to go deeper into the intuition behind the lag for each variable and try to optimize the number of lags for every variable. This could perhaps give us better statistical significances and be more intuitively correct. Let's say for example that the population growth rate has many years of lag, before the born people start contributing to growth. Hence, the lag should probably be 20 years or even more for that variable. That said, the control variables were there to control for the isolated effect of debt on growth, such that it has a value to keep the number of lags the same as for the interest variable. In section 4.2.6, we talked about the importance of getting rid of any serial correlation in the error term and that this is partly corrected for by lagging the effect. When it turns out that we are more interested in the model (1) for developed countries, however, this argument vanishes, as model (1) did not include lagged variables. Even if we assumed no serial correlation in the error term in section 4.2.6, we do not run any test to check this and we cannot be certain about this.

8.6 Endogeneity

Since both the dependent and independent variable consist of GDP, there is arguably some sort of a natural endogeneity since we cannot have GDP growth without affecting the debt-to-GDP ratio. However, this is not a problem because we are interested in the share of debt to GDP and not the growth levels of the debt, whereas the dependent variable is GDP growth from year t-1 to t. If GDP grow by three percent and nominal debt grow by six percent, then debt-to-GDP grows by three percent less than nominal GDP. If GDP grow by three percent and debt stay constant, we get the same outcome that nominal GDP grow by three percent more than the debt. This illustrates that the model still makes sense even though GDP appears in some way both at the lefthand and righthand side of the equation.

Another implication concerning endogeneity is the effect of social control variables we saw in model (4) for developing countries, which only contributed to higher standard deviations and more uncertainty, whereas the estimated coefficient of debt remained close to the estimate in model (3). This contribution of uncertainty by the social control variables might come from an endogeneity problem. There is likely that variables such as population growth and political stability is affected by growth, therefore resulting in an endogeneity issue when using them as independent variables. Since we find that isolating based on both macroeconomic and social factors does not change the estimate (model (4)) compared to only isolating based on macroeconomic variables (model (3)), we would encourage later studies to focus on improving the macroeconomic variables rather than adding more non-economic variables to the regression. We shortly mentioned the possible effects of home- versus foreign currency denominated debt in section 3.1.3 when we introduced the external debt variable. In further research on the debt's effect on growth, we would consider controlling for a potential effect of differences in the currency of a country's debt. The problem with endogeneity raises a concern about causality, but as earlier mentioned causality has not been a focus in this thesis.

9.0 Conclusion

When preparing this paper, we explored the impact of public debt on economic growth and examined whether this effect varies among countries worldwide. In the literature review part of this paper, we provided a historical overview of the topic, discussing various theories and empirical studies related to public debt and economic growth. The extensive review informed the methodology using OLS, leading to the development of a model that incorporates 12 variables and distinguishes between developing and developed countries. A potential turning point in which debt turns bad is not found for developed countries, whereas a turning point at debt levels of 121.58% is suggested for developing countries. This is more than double the average debt levels among developing countries in the data set period. The fundamental differences among developing and developed countries supports the statement from IMF in 2012 that "there is no simple relationship between debt and growth". A "one size fit's them all" approach is likely not a good one when it comes to national debt, motivating a narrower and more qualitative study for further research. Even if the issues with government debt have been discussed for centuries, studies on the actual effects of debt on growth at the precision level we seek here, are relatively recent. It will most certainly appear studies on this topic in a more frequent manner from now on, as debt levels are increasing worldwide, we have in recent decades experienced countries with huge debt problems and interest rates are fluctuating again, after low interest rates during the pandemic.

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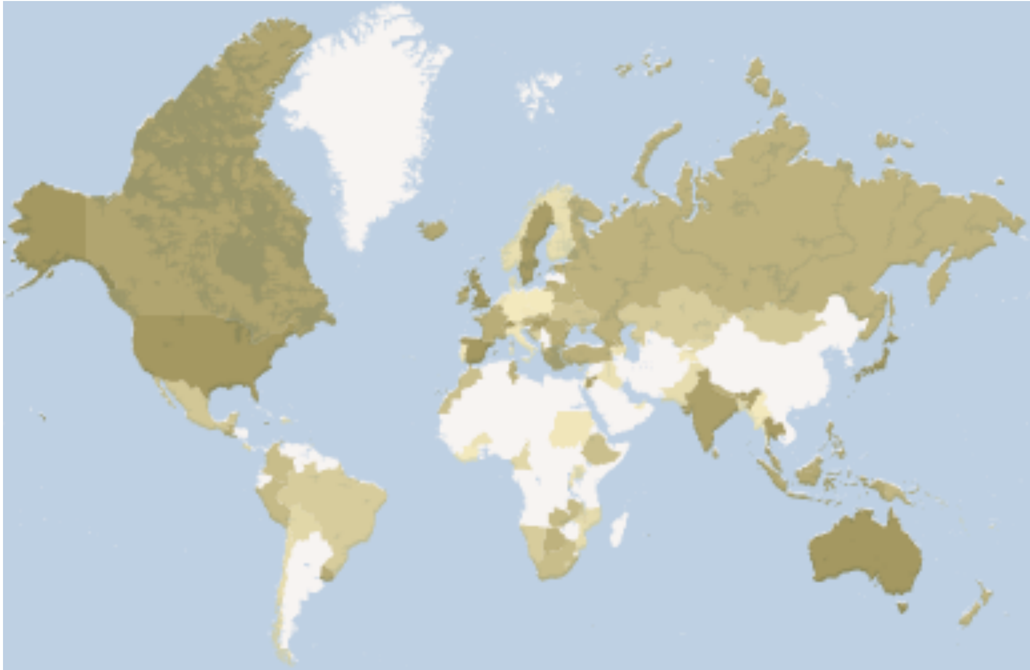
Appendix

Appendix 1: Frequency of appearance of a country in the full dataset



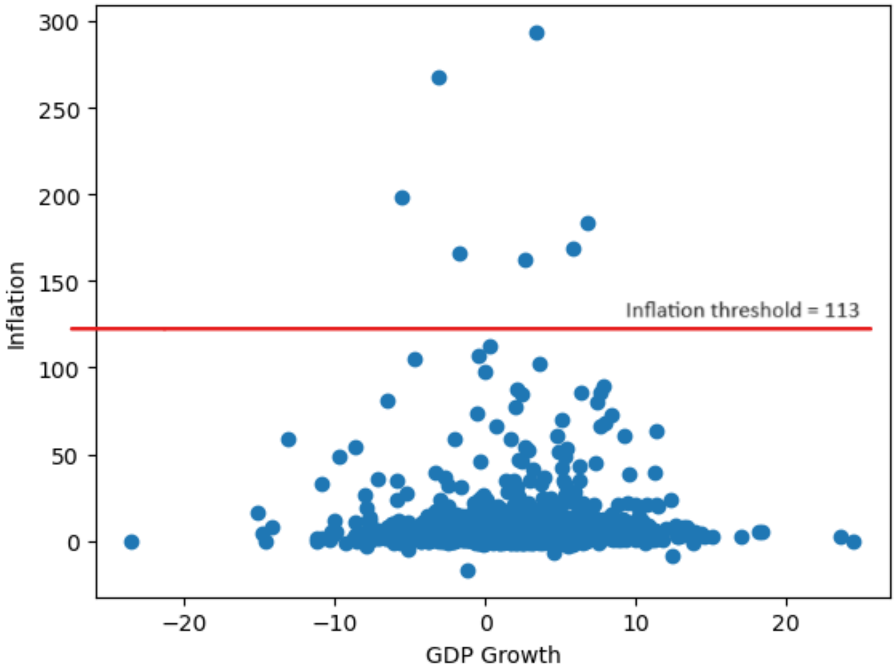
Note: This map shows the frequency of country observations we have in the data set. A dark colour means it appears in all 31 years (like Australia), whereas a white colour means 0 observations for that country (like China). The graphics is made using Power BI.

Appendix 2: GNI per capita threshold for classification of developed or developing country.

Year	Threshold	Year	Threshold	Year	Threshold
1990	2336	**2001**	2996	**2012**	4036
1991	2466	**2002**	2976	**2013**	4086
1992	2556	**2003**	2936	**2014**	4126
1993	2696	**2004**	3036	**2015**	4126
1994	2786	**2005**	3256	**2016**	4036
1995	2896	**2006**	3466	**2017**	3956
1996	3036	**2007**	3596	**2018**	3896
1997	3116	**2008**	3706	**2019**	3996
1998	3126	**2009**	3856	**2020**	4046
1999	3031	**2010**	3946	**2021**	4096
2000	2996	**2011**	3976	**2022**	4256

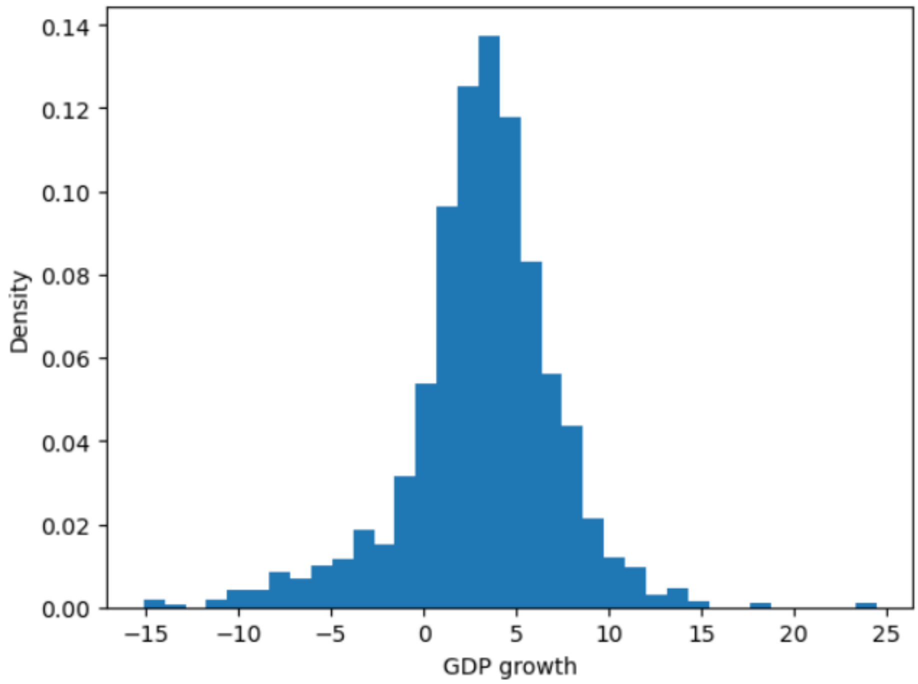
Note: This table shows the World Bank's threshold value for GNI per capita for a country to be classified either a developed or a developing country. This threshold separates the lower-middle countries with the upper-middle countries in the World Bank's traditional four category classification.

Appendix 3: Scatter plots of inflation outliers.



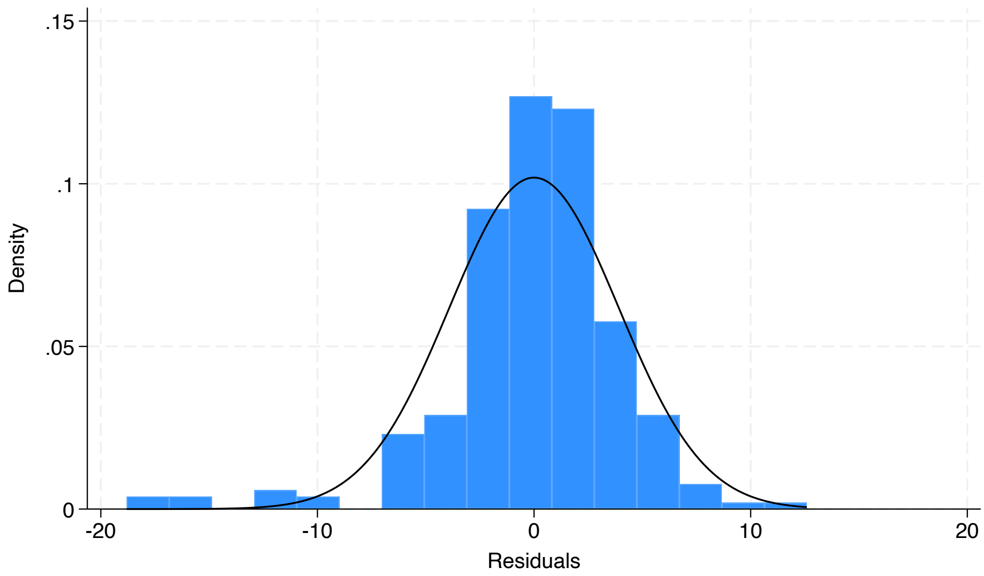
Note: This scatter plot of the inflation rates in the full data set shows the natural gap that appears between a rate of 113% and 162%, the motivation behind the threshold of 113%. The figure is cut at a rate of 300 and does not show the maximum inflation rate observed, mentioned in section 3.2.1.

Appendix 4: Distribution of the growth values



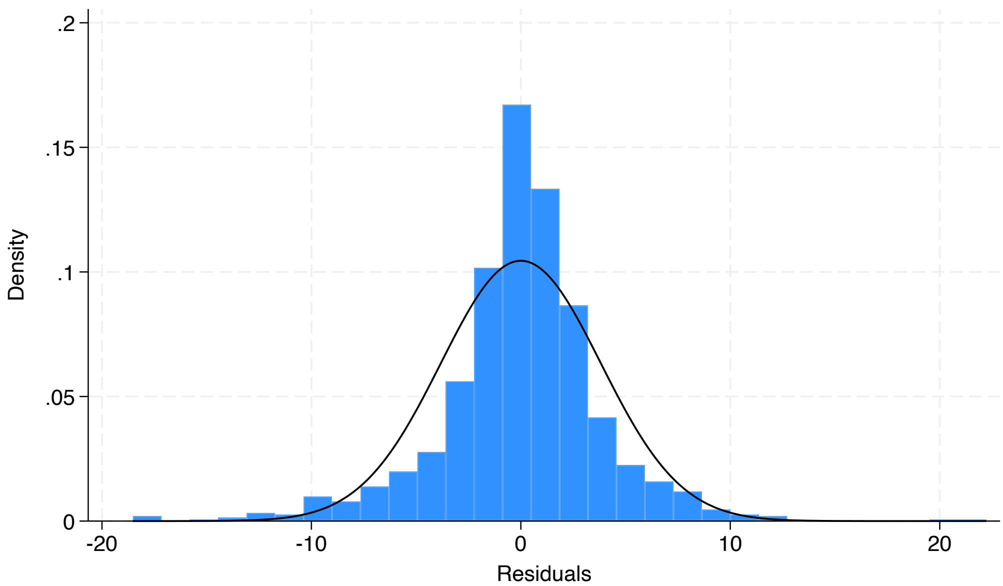
Note: This figure illustrates the distribution of the GDP growth variable with 35 bins and each value's density on the y-axis

Appendix 5: Histogram of residuals from the model for developing countries.



Note: This figure illustrates the distribution of residuals from model (3) for developing countries. The x-axis represents the values of the residuals, and the y-axis represents the density. The density means that the area under each bar corresponds to the probability of a residual falling within that range. The black line illustrates a perfectly normal distribution.

Appendix 6: Histogram of residuals from the model for developed countries.



Note: This figure illustrates the distribution of residuals from model (1) for developed countries. The x-axis represents the values of the residuals, and the y-axis represents the density. The density means that the area under each bar corresponds to the probability of a residual falling within that range. The black line illustrates a perfectly normal distribution.

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