Public debt heterogeneity at country level: an empirical analysis

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Public debt heterogeneity at country level: an empirical analysis *

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Abstract

Nowadays, the increase in public debt is affecting economies around the world reaching unprecedented values. In light of that, this paper investigates the effects of taxes and public spending as debt deflators. Moreover, it compares how a boost in inflation with respect to traditional instruments might help debt-to-GDP reduces. Eventually, this paper highlights the importance of the economy size as a key feature that policymakers should consider in making judgments.

For these purposes, we use a fixed effects regression on a balanced panel data from 2005 to 2020 assessing how inflation, taxes, and public expenditure impact the dependent variable, namely the public debt-to-GDP ratio.

Overall, we found that an increase in inflation and tax revenue entails different effects on the economic growth for both the United States, the European Union and China. Moreover, a consistent increase in public expenditure causes a decrease in the public debt-to-GDP ratio in all three nations. The divergent political stances and the evolution of the three countries create a huge heterogeneity among them and high values of heterogeneity in terms of public debt within the nations.

JEL Classification System: C23, E31, E44, F43

Keywords: debt-to-GDP, Inflation, Tax Revenues, Government Expenditure.

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1 Introduction

In the wake of the pandemic outbreak, public debt is increasing among all countries, regardless of the economic size of the nation. Specifically, the debt-to-GDP has reached the value of 95.6% in the European Union (Eurostat, April 2021), far from the threshold imposed by the Stability Growth Path of 60 percent. At the same time, the national debt of the United States reached 137.20%, the highest value observed. Moreover, it is predicted to rise even further. Eventually, China's national debt is increased up to 69% in 2021.

Hence, today more than ever the analysis of different instruments that might be used as deflators of public debt, go back to being relevant. In this regard, it is important to consider that economies employ different factors to deflate their deficits: while Federal Reserve (Fed, hereafter) bases its policies on the average development of all the US states (Fed, 2021), the European Central Bank (henceforth, ECB) must orient itself in favor of the weaker countries (Eurostat, 2021). China, instead, bases all the decisions on the area of Beijing (Michaels, 2015).

In light of that, this paper asks two main questions: **First,** what is the impact of inflation, tax revenues and government spending on the public debt-to-GDP ratio? **Second,** how does such impact differs based on the economy type in a dynamic perspective?

To answer these questions, we perform different analyses by using regression models to investigate the interaction between inflation and traditional fiscal policy instruments on the public debt-to-GDP[1], both globally and for specific countries**.** Specifically, a univariate analysis showing the public debt-to-GDP ratio path from 2005 to 2020 is carried out. Moreover, while assessing debt heterogeneity across countries, we take into account US, EU, and China economies. Furthermore, we perform a correlation analysis on the variables, namely inflation, tax revenues, and public spending. Eventually, we input the variables into a fixed effect model regression on balanced panel data.

This paper contributes to the empirical literature that focuses on inflation, tax revenue and government expenditure as public debt deflators (Hilscher et al., 2022; Fukunaga, 2020 and Agoraki et al., 2022, Connolly, 2016 and Wu and Lin, 2010, Checchetti et al., 2011; Chang and Chiang, 2009 and Kumar and Woo, 2010). However, as far as we know, there are no contributions considering all deflators together and comparing their impact on different types of economies.

Moreover, existing studies consider USA and EU or a pooled sample of developed economies (Wu et al. 2010; Alfò et al. 2020) neglecting emerging ones. Instead, this work also includes the analysis of China's economy that, given its history and its fast evolution in the time, best represents emerging market economies.

[1]To isolate the role of taxes, we assume that tax on return is the only kind of tax in the economy following Le Van et al. (2018).

Eventually, differently from existing literature, we carry out the analysis assessing both the impact of the 2007 financial crisis and the pandemic.

Our results can be summarized as follows: **First,** with a substantial increase in inflation, the impact on the economic growth of China is minimal. Instead, even a decimal percentage point difference in inflation can be crucial for both the US and EU. This result was already evident from the univariate analysis where China presented the highest range. **Second,** an increase in tax revenues entails public debt reduction both in the US and in China. The opposite is for the EU economy. We reached the same results by analyzing the descriptive statistics: EU presents the highest among the minimum values as well as the highest maximum values. **Third**, in all three economies a cut in public spending helps reduce the ratio.

Due to the differences both in the evolution of the economy and the divergent political stances of the three countries, a huge debt heterogeneity among the nations emerges. In light of that, it would be useful for policymakers to not only rely on their history and economy but investigates other countries strategies. Furthermore, implementing preventive measures would ensure a fast reaction in period of crisis.

The rest of the paper is organized as follows. The literature review on public debt-to-GDP, inflation, tax revenues and government expenditure is introduced in Section 2. Section 3 presents the univariate analysis, where the preliminary evidence is presented. The empirical methodology that employs fixed effects for data panel regression is illustrated in Section 4. The sample and the variables description are shown in Section 5. Following, in Section 6 we discuss the main results of our exercise. In Section 7 we present robustness checks for our model. The last section summarises the main contribution of the study and gives some perspective for further research.

2 Literature Review

The main front of the literature on public debt to GDP ratio focuses on the impact of the aforesaid measure as a proxy to indicate the economic growth of a country (Beqiraj et al, 2018). Most of the studies use experimental or semi-experimental models to explain the economic growth of countries. Furthermore, almost all the studies focus either on a sample of developed economies randomly pooled or on a representative number of emerging economies when data is available.

Chudik et al (2017) investigate the relationship between public debt expansion and economic growth by means of Monte Carlo experiments. Their results suggest that the economic growth of an emerging economy can be better explained by the trajectory of the debt to GDP ratio than by its actual level of it. Instead, Eberhardt and Presbitero (2015) investigate the relationship between public debt and long-run growth in a large sample of

countries. They find an inverse relationship between economy growth and the increase of public debt.

Other research have verified the size of the debt threshold by means of regression methodologies. Cecchetti et al. (2011) determined a critical level of 85 percent for OECD nations after which public debt starts to be harmful for growth. Based on a similar approach, Caner et al., 2010, Elmeskov and Sutherland, 2012 reported even lower turning points around 70 percent after which the impact of sovereign debt is bad. In contrast, Chang and Chiang (2009) found an inverted U-type relationship: the impact of the debt ratio is positive in any case, but higher in the middle regime and lower in the two outer regimes. Following Kumar and Woo (2010) initial public debt has a negative impact on subsequent growth in a mixed sample of industrial and emerging countries. On average, a 10 percentage point increase in the initial debt to GDP ratio is associated with a slowdown in real per capita GDP growth of 0.2 percentage points per year. Panizza and Presbitero (2012) have argued that a negative correlation between government debt and growth does not imply causality. Hence, a small increase in public spending might result in a decrease in public debt to GDP ratio for specific countries.

Among the studies we found a generous amount of agreements on the measures employed by policymakers to deflate the public debt to GDP ratio. By increasing inflation or the tax revenue, a decrease in the public debt might occur. An increase in general expenditure, instead, would inflate the public debt.

The magnitude and the endurance of global deficits, as well as the variation of balancing methods over time and across countries, have drawn attention in both the theoretical and the empirical fields. One of the main concerns lies in the fact that countries' deficits are mostly linked to persistent inflation and macroeconomic instability (Saleh and Harvie, 2005; Tekin-Koru and Zemen, 2003; Hossain and Chowdhury, 1998).

There are numerous studies that by using different methodologies demonstrate an inverse relationship between economic growth and the increase of inflation from a certain threshold between 10 and 20 percent (Easterly et al., 1994; Gylfason and Herbertsson, 2001 and Loungani and Swagel, 2003).

On the contrary other studies demonstrates that the increase in inflation deflates the public debt to GDP ratio. Reinhart and Rogoff (2010 a b) construct a historical dataset on public government debt to search for a systemic relationship between high public debt levels growth, and inflation. The study is carried out on both developed economies and emerging ones. They find that both emerging countries and developed ones react in the same way to an increase in public debt to GDP but not in the case of an increase in inflation. Herndon (2013) starting from Reinhart and Rogoff (2010 a b), shows a difference between the economic growth both at country level and by time-period considered. Their results show that inflation increases in periods of crisis for emerging countries. Differently,

Hilscher et al (2022) study how inflation modifies the burden of debt in the US. They envisage that an increase in inflation will unlikely lower the real value of debt if not by a few percentage points of GDP. Akitoby et al (2014) investigate the impact of low and high inflation on the public debt to GDP in advanced economies. They suggest that an increase in inflation could help reduce the public debt to GDP under the Fisher Effects[2]. Using different methodologies also Kause and Moyen (2013), Fukunaga (2020) and Agoraki et al (2022) argue that an increase in inflation acts like a deflator of debt in the OECD, developed economies and the EU area respectively.

Another strand of literature focuses on the impact of tax revenues on public debt and whether or not an increase in taxes would deflate the public debt enough to be employed by policymakers in different settings.

In this regard, Korkmaz et al (2022) through an OSL regression demonstrate that by ensuring stability in tax revenue, countries would help their economic growth. Knellera et al (1999) analyze the effect of an increase in taxation on economic growth by a regression. Their results show that an increase in taxation acts as a deflator for the public debt. Yankkaya et al (2020) empirically examines the effect of taxes on countries' economic growth. They find that taxes act differently depending on the status of the country taken into consideration. On the opposite, Alfò et al (2020), show a negative impact of taxes on public debt supporting the idea that taxes are generally harmful to economic growth.

A growing body of empirical literature study the impact of general expenditure on public debt to GDP ratios. Using fixed effects regression Connolly (2016) found that government spending has no significant effect on economic growth for a pooled sample of 34 OECD countries. Similarly, Wu and Lin (2010) supports both Wagner's law[3], and the hypothesis that government spending is helpful to economic growth. Instead, Lora and Olivera (2007) argue that government expenditure creates a paradox in the matter of public debt to GDP ratio. Indeed, in the short term an increase in public spending would increase the public debt. However, countries that do not cut their government expenditure in times of crisis might benefit from this in the long run. Chu et al (2020) examine the relationship between the compositions of government expenditure and economic growth both in developed and emerging countries. They find that emerging countries do benefit from an increase in government expenditure. Moreover, the increase helps developing countries in catching up with developed ones. Lahirushan et al (2007) by using random OLS regression analyze the impact of government spenditure on economic growth in Asian countries (mostly emerging economies). Their results show an inverse relationship between government spenditure and public debt to GDP ratio.

[2]The Fisher Effect refers to the relationship between nominal interest rates and real interest rates and inflation expectations. The relationship was first described by the economist Fisher in 1930.

[3]Wagner's law posits that during the period of industrial revolution, the share of public expenditure in total expenditure increased as real income per capita of the nation increased. Thus, it is economic progress or development that elicits the expansion in the relative size of the public sector Wagner and Weber (1977)

3 Univariate Analyisis

This section presents a univariate analysis by illustrating the heterogeneity among the three countries. Figure *1* shows the path of public debt-to-GDP ratio throughout the years.

Right at the beginning of our time series the differences among the three countries are evident. From the start of 2005, both the US and EU public debt to GDP rations float way higher than China, with EU being almost 45 percentages point above China.

The US and the EU start diverging from one another after the 2007 financial crash, both countries experienced a peak in the ratio due to the high debt, which consequently enlarged the debt-to-GDP ratio. The two nations arguably never recovered from this crisis. Moreover, the 2007 crisis is not only a key moment for our time series but more in general for US history. The US debt-to-GDP ratio rose to the top, leaving both China and Europe far behind.

Interestingly, after the Financial Crisis the US ratio kept on growing steadily but slowly due to the monetary fiscal policies adopted by the country to balance the debt and the GDP. The steadiness was kept until 2020 when the US experienced the highest percentage increase in the debt ratio. This increase might be due to the poor regulamentation concerning employment, which consequently lowered the GDP of the nation. Therefore, the decrease in the GDP increased the public debt to GDP ratio (Reinhart, Rogoff, 2010).

On the other hand, while both the EU27 area and the United States followed a similar path, China has had its journey through the highs and lows of the debt-to-GDP ratio throughout the years. It is indeed important to state that in 2005, when our time series starts China was a newly emerging economy, and due to this the GDP grew slowly. Therefore, the Debt to GDP ratio did not catch up to the powerhouses that are the European Union and the United States (Barth et al., 2009).

The differences in history and the divergent political stances of the three countries created a huge heterogeneity among them. Moreover, the 2007 crisis and subsequently in 2020 with the COVID-19 pandemic, created heterogeneity within the areas. Hence, the need to check the heterogeneity at country level before running the regression.

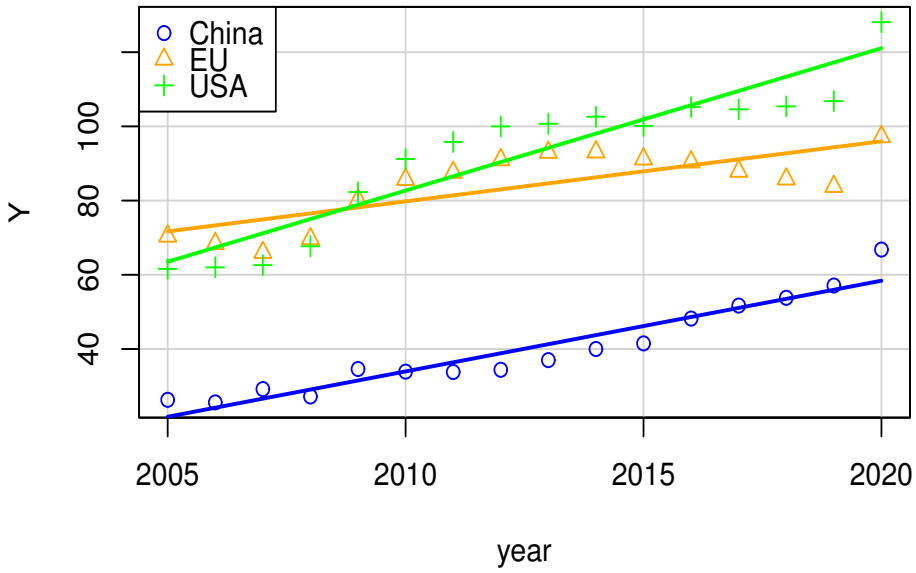

Figure 1: **Public debt over GDP ratio throughout the years in the three Countries**

Figure *2* shows how different the countries are from each other. The public debt-to-GDP ratio has high heterogeneity among the countries, in particular between China and the two developed economies of US and EU. Moreover, a high heterogeneity can be observed within the US.

In line with Eberhardt and Presbitero (2015), our results show how big of an impact heterogeneity has on countries. It is clear how China is trying to catch-up with well-established economies, that on the other hand float way higher than China in regards of high Debt over GDP ratio. Looking, instead, at the within heterogeneity the biggest gap is in the US. This is due to the difficulties the country experienced in the journey to recovery from the 2007 crisis before running into a new one.

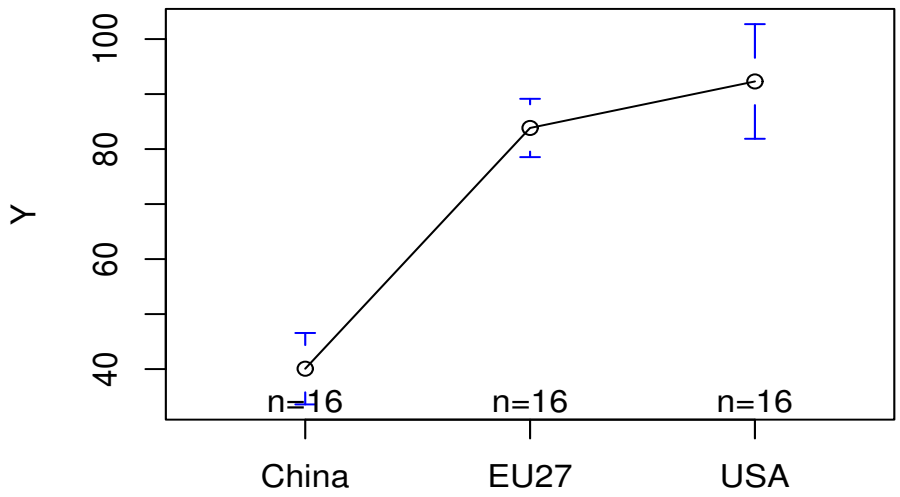

Figure 2: **Heterogeneity across Countries**

4 Empirical Methodology

This section displays the empirical methodology we employ to study the behavior of the public debt-to-GDP ratio across the countries.

We consider fixed effects (hereafter FE) for data panel regression, as we aim to analyze how variables change over time and how they impact dependent variable, namely the public debt-to-GDP ratio. To this end, the FE model removes the effect of the time-invariant characteristics, enabling us to assess the net effect of the predictors on the outcome variables.

As for variables' choices, tax return and government expenditure are employed as traditional instruments used to deflate the public debt-to-GDP ratio. Moreover, starting from the current debate among economists underlying which there is the assumption that inflation could reduce public debt, we include in the analysis this variable too[4].

Moreover, since our sample considers both the 2007 financial crisis and the 2020 pandemic and their aftermaths, we include them by means of a dummy variable.

We perform four different regression models. Model I is our general regression that is run on the variables independently of the specific country. The other models are run with the country's respective values. Therefore, the three models are run on the values of US,

[4]The exponential of the inflation is used to capture the behavior of the public debt-to-GDP when the inflation raises exponentially.

EU and China respectively Model II, III and IV.

Equation *1* is the regression we base our four models on.

$$Y_{(k,t)} = \alpha + \beta_1 i_{(k,t)} + \beta_2 e^i_{(k,t)} + \beta_3 t_{(k,t)} + \beta_5 GE_{(k,t)} + \beta_6 D\_c + \varepsilon_{(k,t)} \tag{1}$$

Where $Y_{(k,t)}$ is the dependent variable and represents public debt to GDP ratio. The independent variables are: i that represents inflation, t for tax revenues and GE for general expenditure, D_c is the crisis dummy variable. α is the intercept.

Finally, ε is the country and error term it helps by capturing a potential missing (or omitted) variables problem.

5 Sample and variables description

This analysis employs a balanced fixed data panel of 16-year period covering the three countries. Therefore, final sample is made of 240 observations. The dependent variable is computed as the public debt over GDP ratio sampled from the World Bank Database. For the independent variables we consider Inflation, Tax Revenue and Government Expenditure[5] retrieved from Eurostat (For European Union), from FRED (for the U.S.A.) and lastly from the National Bureau of Statistics of China (for the aforesaid country). The three independent variables are all normalized to the GDP of the areas to make possible for next analysis comparisons.

Our sample covers the period from 2005 to 2020. The starting date is chosen because it is before the financial crisis and it can give us a general view of how countries' debt to GDP ratio behaved before it. Our ending date is 2020, it was the last available date for all the countries considered.

The original data obtained has been already treated for missing values and screened for outliers. Table *1* shows the descriptive statistics that ensure the variables fall within acceptable ranges and skewness.

From the descriptive statistics, we can already observe the preferred deflator methods for each of the countries. For what concerns the public debt-to-GDP ratio the mean among the countries is 72.01%, more than 20 percentages points below the highest mean that is found in US. For this variable, the mean is lowered by China since being an emerging economy reached economic growth' level lower than the other two.

Inflation has the lowest range among the three countries (6.66%). In line with the literature, the EU uses inflation as the main debt deflator has the lowest percentages range

[5]For what concerns general expenditure the military expenses have not been taken into consideration as they would askew the distribution for these particular variables. Moreover, they would distort the result of the regression since they are among the highest expenses for the US but not the other two countries considered.

(1%), meaning that even a small change in the independent variable can have a significant impact on the country's debt-to-GDP ratio.

Taxation has a higher mean for both the EU and China, but only the European Union taxation range is as low as 1%. This is due EU political decision of not to manipulate this policy tool to deflate the debt-to-GDP ratio. The US taxation percentage range (3.8%) is more in line with the range of emerging economies, in our case China (4.6%), than the one presented in advanced economies, in our work the EU (1%).

General Expenditure, in line with the literature, is used only in times of crisis both for the US and EU, and has the highest range among the three independent variables.

When observing China, their results might not be instantly clear when confronted with the other two countries, no variable seems to have a bigger impact than the others to help the public debt-to-GDP ratio. Given China's history it is normal that being an emerging country it has not yet found the best deflator policy strategy. Therefore, in an attempt to balance the ratio it uses a mix of all three of the variables.

Variables	Obs	Mean	Std. Dv.	Min	Max
Y	48	72.01	27.10	25.60	128.10
Y(US)	16	92.29	19.56	61.60	128.10
Y(EU)	16	83.67	9.96	68.00	97.20
Y(China)	16	40.07	12.19	25.60	66.80
i	48	1.98	1.33	−0.73	5.93
i(US)	16	1.99	1.15	−0.36	3.89
i(EU)	16	1.36	0.82	0.10	2.90
i(China)	16	1.45	0.68	−0.73	2.42
t	48	16.34	4.44	7.90	21.30
t(US)	16	10.29	1.01	7.90	11.70
t(EU)	16	19.73	0.29	19.10	20.10
t(China)	16	18.91	1.50	16.10	21.30
GE	48	48.38	10.69	35.68	82.10
GE(US)	16	39.23	2.61	35.68	44.00
GE(EU)	16	48.31	2.08	45.60	53.40
GE(China)	16	57.61	12.92	42.00	82.10

Table 1: **Descriptive statistics**

6 Empirical Analysis Results

In this section the main results are explained, firstly by analyzing the different monetary policy tools and then by observing the regressions' output. Moreover, we will show the correlation matrix on the variables both generally and at country level.

Throughout the years the behaving of the economic growth of the three countries presented in this study varied due to the different strategies that policymakers adopt to either lower the debt or increase the GDP. In the light of the information given in the preliminary evidence, the general regression shown in the Figures *3-5* [6] cannot explain alone the three countries' behavior to the best. Therefore, in the same graphs the single country' regression can be observed alongside the general regression.

The first step in the analysis is to study the the effect of inflation on the public debt over GDP ratio. Figure 3 shows the regression of inflation over debt-to-GDP ratio. In line with the literature general regression has a steep negative inclination. Observing the three countries' regressions respectively, it is clear how the general regression can't explain to the fullest the effect of inflation on debt to GDP ratio.

Our results can be summarized as follows: the Euro Zone regression (orange line) lays over the general regression but is steeper and shorter. This can be explained by the fact that if a sudden increase in inflation rates would come too early for those countries with a weaker economy then they would be less likely to recover from it. Inflation in the EU area never changes more than two percentage points per year. In line with the new directives explained by Hannecke (2021) the new updated ECB monetary policy strategy in an effort to deflate the debt is pushing inflation upwards. Moreover, inflation is the instrument preferred by European policymakers because it appears to be the quickest debt deflator for the EU.

The regression concerning the inflation in the USA (green line) has a negative inclination. Instead, the European Union regression line is much smoother. Even though in the United States of America inflation has positively affected the debt-to-GDP ratio multiple times throughout history, it is not the preferred tool (Kiley,2015).

For what concerns China, the results we obtain with inflation (blue line) show a negative inclination, the smoothest out of the three countries. Therefore the tool is not a particularly strong debt-to-GDP deflator. Moreover, since China has not picked yet the optimal strategy it has used inflation just as much as all the other forms of deflators in an attempt to catch up to the powerhouses that are the European Union and United States (Barth et al., 2009).

Another step in the analysis is to study how the countries react to an increase in tax revenues first a whole and then at the specific country level. Theoretically, higher taxation should increase the countries' GDP and therefore lower the public debt-to-GDP ratio, but

[6] The general regression is shown in red. For the European Union regression we can observe the orange line with the variables in triangular shapes. For China the regression is in blue with the respective variables as circles. Lastly in green the outcome of regression of the U.S.A. with plus signs to indicate the variables.

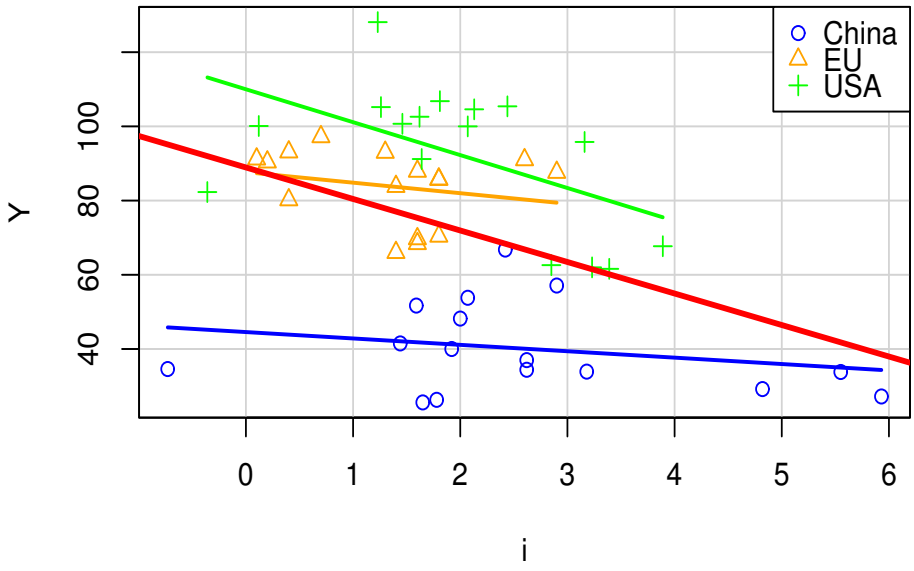

Figure 3: **Regression of Inflation over Public Debt to GDP Ratio**

in the case of the Euro Zone the results are in contrast with the economic theory. Figure 4 shows the output of the regression we obtain with tax revenue as a regressor of the public debt-to-GDP ratio. In the general regression the inclination is negative but not steep like the one we observed with inflation.

It is important to point out the correlation that occurs in this specific case for what concern the inclination of the regression line. Per the Fisher Effect, nominal rates of return generally move with inflation when investors demand higher nominal returns to offset the impact of expected inflation.

The European Union (orange line), presents a steep positive regression in contrast with the general economic growth theory. The European Union has always been on the higher side of the taxation and historically has not used it as a debt deflator tool (Stoilova, 2017). Therefore, given the strong correlation that occurs between taxation and inflation and since that inflation is the preferred tool for the European Union, both instruments cannot be considered independently from each other.

Due to the everchanging taxation policies the US and China have experienced multiple changes for what concerns taxation. Both countries react to increases of the public debt-to-GDP ratio more quickly with an increase in tax revenue rather than in inflation. Therefore, in these cases their regressions have a negative inclination, in line with the literature.

This particular tool seems to work best for China (blue line). Public debt quickly deflates to the minimum change in tax return increase. This is due to China being an emerging country and not picking the best form of strategy to lower the debt-to-GDP ratio.

Consistently with the results of Morozov (2017), in the United States (green line) an increase in tax revenues helps the public debt over GDP ratio. Quite interestingly it emerges that, in the U.S.A., once tax revenue increases above 10% it stops being a strong debt deflator, indeed, public debt increases.

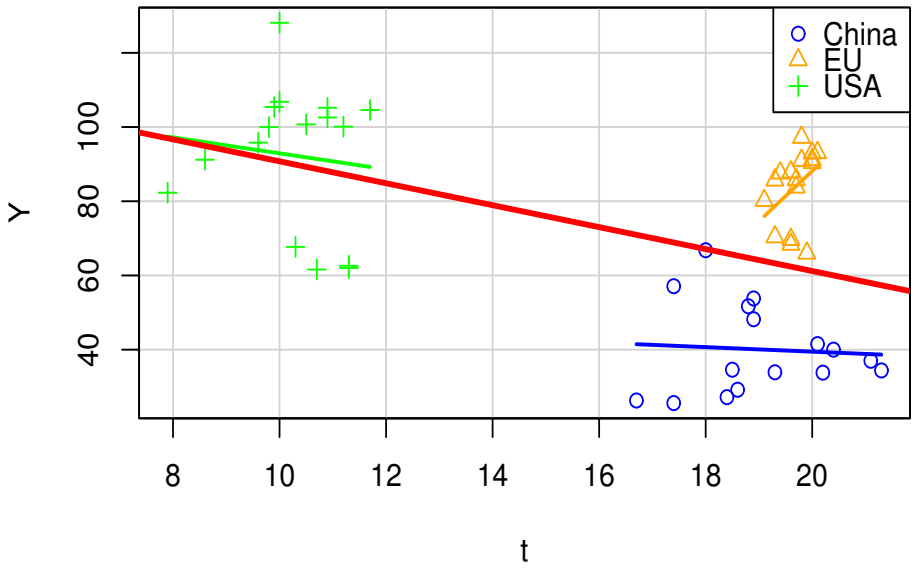

Figure 4: **Regression of Tax Revenue over Public Debt to GDP Ratio**

Let's now observe the last independent variable. Figure 5 shows the effect of a decrease in government expenditure on the public debt-to-GDP ratio. The general regression is positive and steep, in line with literature.

The three countries all follow the expected sign and inclinations. Specifically, the United States (green line) and the European Union (orange line) have very similar regression in terms of tendency and government expenditure percentage change throughout the years**.**

In line with the results obtained by Wang and Wen (2013) , China is below the other two countries for what concern government expenses. Moreover, it differentiate from the US and EU since the range of percentage change in China is the highest among the three countries. Being an emerging country country, China (blue line) do not present a high change in public spending. Moreover, China offers a unique opportunity to test the Keynesian notion on government expenditure multiplier[7], given its long percentage range.

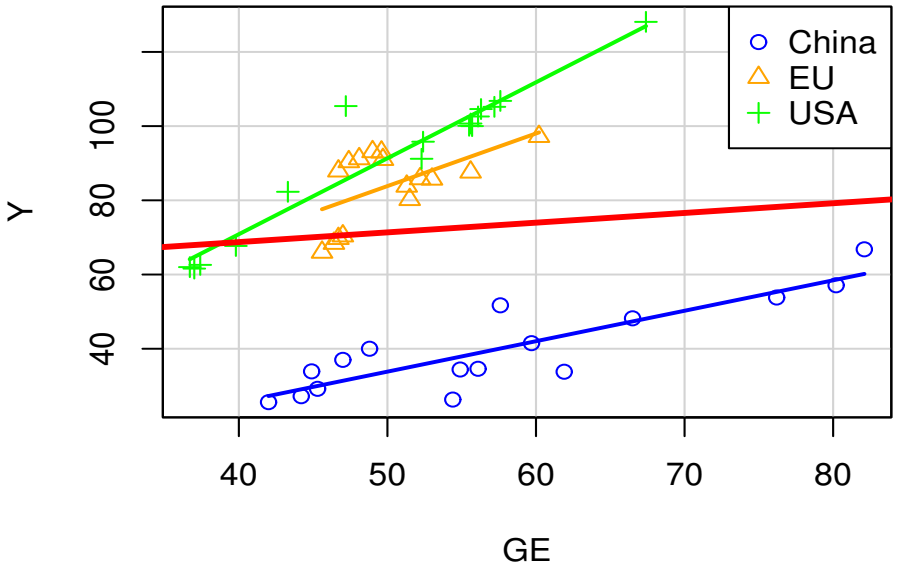

Figure 5: **Regression of General Expenditure over Public Debt to GDP Ratio.**

The second to last step before running the regressions is to check the correlation between the variables. Therefore, Table *2* shows the correlation among the variables. The

[7]The Keynesian Multiplier is an economic theory that asserts that an increase in private consumption expenditure, investment expenditure, or net government spending (gross government spending – government tax revenue) raises the total Gross Domestic Product (GDP) by more than the amount of the increase.

strongest correlation is between tax revenue and government expenditure (both independent variables), reaching the value of *0.73117205*.

The relationship between government expenditure and government tax revenue is important for fiscal policymaking and macroeconomic management. The nature and composition of government expenditure influence economic growth and social welfare. Therefore, government expenditure, influences government tax revenues as well.

	Y	i	t	GE	D_c
Y	1				
i	−0.418660	1			
t	−0.48239	0.731172	1		
GE	0.09513	−0.08907	0.105353	1	
D_c	0.13327	−0.39288	−0.06682	0.28699	1

Table 2: **Correlation among variables**

To overcome the correlation between some of the independent variables the Fix Effects model has been chosen as the best regression model for the panel data presented in this study.

After selecting the Fixed Effects Model the regressions are run based on the four models: Model I is the general regression; Model II is the regression that takes into consideration the variables of the USA. Model III and IV are the regressions run on the EU and China values, respectively. Table 3 reports the output of the regressions, the standard errors are reported in parentheses below the estimated values. The superscripts ***, **, and * denote coefficients statistically different from zero at the 1%, 5%, and 10% levels, respectively, in two-tailed tests.

Lowering the government expenditure has a significant and positive effect on the public debt in all the models. This positive effect means that an increase in government expenditure inflates the public debt-to-GDP ratio. An increase in inflation hurts the economic growth in all three models with the strongest impact in EU. This means that an increase in inflation decreases the public debt-to-GDP ratio in all three countries and the overall regression.

Moreover, an increase in taxation helps the debt-to-GDP ratio both for the US and China. Europe does not follow the expected sign since tax revenues are not used yet as a deflator tool for European policymakers. Moreover, only for the general regression taxation is significantly negative.

Our results show that increasing inflation there is no impact on the economic growth of China. Instead, for the two developed economies even an increase of decimal percentage points in inflation reduces the public debt-to-GDP ratio. When we look at the tax revenue

Coeff	Model I	Model II USA	Model III EU	Model IV China
Intercept	25.2439**	3.3785.	84.9245.	25.7579.
	(3.3194)	(23.5543)	(44.6328)	(20.7567)
i	-6.6510**	-2.6039*	-7.4399**	-1.615*
	(3.3194)	(3.4733)	(5.5651)	(2.2632)
exp(i)	0.04981	0.2826	1.1789	0.03815
	(0.03640)	(0.3110)	0.9760	(0.03273)
t	-3.49144***	-0.9324	4.1854*	-1.02214
	(0.30659)	(1.9655)	(3.8972)	(0.458756)
GE	3.26290***	1.9098***	1.4753*	0.75975***
	(0.61062)	(0.2538)	(0.5064)	0.15119
D_c	0.83937***	3.9066*	8.0455*	4.16408*
	(0.23091)	(6.7090)	(6.8790)	(6.37173)

Table 3: **Results of thel Regressions.** Note: 0 "***", 0.001 "**", 0.01 "*", 0.05 ".", 0.1 " "

impact the situation is different as prevention plays an important role. Hence, a boost in taxation inflates the public debt ratio in the EU, while it acts like a deflator in both the US and China. Ultimately, we found that all three nations behave the same when a consistent increase in public expenditure occurs. All the countries in our work undergo a decrease in the public debt-to-GDP when government spending gets major cuts. Since the differences in history and the divergent political stances of the three countries create a huge heterogeneity among them and at the same time high values of heterogeneity within the nations are created, it would be useful for policymakers to not only rely on their history and economy but investigates other countries strategies.

7 Robustness

For the sake of completeness and to run a robustness check in Table 4 we run the Hausamn test. This test is performed to decide which of the two models is statistically valid. The null hypothesis is that the preferred model is the random effects model, whereas the alternative hypothesis is that the preferred model is the fixed effects model.

	Fixed	Random	Var(Diff)	Prob
i	0.001440	0.001692	.0	.000
GE	0.001681	0.002872	.0	.000
t	0.003713	0.001499	.0	0.00034

Table 4: **The Hausmann Test Results.** Note: Chi-sq 48.148 (2); Test Summary Prob 0.000.

As probability is .000 we reject the Null Hypothesis (where the Null Hypothesis is that the preferred model is the Random Effects one). The rejection of the Null Hypothesis in the Hausmann test confirms that the Fixed Effects method is the right one to use in this case (Green, 2008).

No correlation occurs between the unique errors and the regressors in the model has been detected. Moreover, the assumption of the residuals are satisfied in this model by running graphical tests. By means of graphical tests, namely the QQ plot, we assess that the set of data plausibly comes from normal distribution. The results are in line with the literature, since the residuals are normally distributed.

Furthermore, to detect non-linearity, unequal error variances and outliers we use a residual vs fitted graphical analysis. We found that only three assumptions of the residuals are checked, as we expected:

- The residuals "bounce randomly" around the 0 line. This suggests that the assumption that the relationship is linear is reasonable.
- The residuals roughly form a "horizontal band" around the 0 line. This suggests that the variances of the error terms are equal.
- Two residuals "stands out" from the basic random pattern of residuals. The 2020 public debt of the US and EU. Therefore, this suggests that there are no outliers in the residuals that we did not take into account.

8 Conclusions

The increase in public debt is affecting economies around the world reaching unprecedented high values in history, both for developed and emerging economies. At the same time, inflation i raising more than ever. In light of that, it is interesting to study how inflation and traditional debt deflating tools influence the public debt-to-GDP of the nations.

This is what we do in this paper. Specifically, with a fixed effects panel data regression we analyze the impact of inflation, tax revenues and government spending on the economic growth of a country. To our knowledge, this paper is the first attempt to study different ways in which public debt reacts to inflation and traditional fiscal policy instruments considering three different type of economies, including US, EU and China.

Our results show that an increase in inflation does not have an impact on the economic growth in China. Instead, for the EU and the US even an increase of decimal percentage points in inflation reduces the public debt to GDP ratio. Moreover, a boost in taxation inflates the public debt in the EU, while it deflates the ratio in both the US and China. Lastly, a consistent increase in public expenditure causes a decrease in the public debt to

GDP ratio in all three countries. The differences in history and the divergent political stances of the three countries create a huge heterogeneity among them and high values of heterogeneity within the nations.

Hence, the Covid-19 pandemic and the most recent war require further stimulating measures by the government. In other words, not adopting preventive measures, in the case of the US, will predictably lead to even higher debt growth in the years ahead due to countries not being able to extinguish the debt burden.

Our work leaves out several variables that might be interesting to include in future studies. Creating jobs, raising incomes and restoring the investors' confidence could, potentially, help decrease the public debt ratio as well as the other methodologies aforementioned. Thus, it would be useful include in the analysis internal and external investments and employment. In this way, it would be possible to employ a more sophisticated empirical model. Furthermore, it would be interesting input quarterly values and use time series modes with the Box and Jenkins approach to check for the heteroskedasticity and autocorrelation consistency of the error terms. We leave these extensions to future research.

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