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# The dynamic interdependencies between Income Inequality, Public Debt, and Inflation Rate - a PVAR Model approach

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Master in Economics

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Department of Economics

Department of Political Economy

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*Para a minha família e amigos*

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# Resumo

A vigente dissertação apresenta uma análise empírica sobre a relação entre desigualdade de rendimentos, inflação e divida publica, em 14 economias desenvolvidas. Para tal, estima-se um modelo Panel VAR onde se analisa a relação endógena entre as variáveis, para dados anuais em painel entre 1980 e 2019. Este estudo, ainda, inclui a utilização de um modelo heterogéneo, Global VAR, onde as especificações individuais dos países são tidas em conta. Em relação ao modelo homogéneo, conclui-se que a variação positiva de desigualdade de rendimentos resulta num decréscimo da dívida pública durante 4 anos, após a introdução do choque. Por sua vez, uma variação na dívida pública resulta num decréscimo da desigualdade de rendimentos, no momento do choque, seguido de um crescimento da desigualdade no médio-prazo ($2^{o}$ ano até ao $4^{o}$ ano). Um choque na inflação diminui a acumulação da dívida no curto-prazo ($1^{o}$ ano), apresentando uma tendência positiva e significativa a partir do $2^{o}$ ano. Nos resultados do modelo heterogéneo, vemos que os países com resultados estatisticamente mais significativos são: Portugal, Espanha, França e Itália. Nestes casos, os resultados refletem significância estatística nas respostas do Índice de Gini, tanto num choque na inflação, como no aumento da dívida pública. Até à data, este trabalho é pioneiro, visto que a relação entre estas variáveis nunca foi explorada empiricamente, nomeadamente num contexto de análise temporal.



**Palavras-chaves:** Índice de Gini, Desigualdade de rendimentos, Dívida pública, Inflação, Panel VAR, Global VAR

**Classificação JEL:** C32, E17, E21, E32, E60, F34

# Abstract

The current dissertation presents an empirical analysis of the relationship between income inequality, inflation, and public debt in 14 developed economies. For this, a Panel VAR model is estimated for an annual balanced panel data between 1980 and 2019, where it is taken into account the endogenous relationship between the variables. This study also includes the use of a heterogeneous model, Global VAR, where individual country specifications are taken into account. In relation to the homogeneous model, it is concluded that the positive change in income inequality results in a decrease in public debt over 4 years, after the introduction of the shock. In turn, a change in public debt results in a decrease in income inequality, at the time of the shock, followed by an increase in inequality in the medium term (2nd year to 4th year). A shock to inflation reduces the accumulation of debt in the short term (1st year), showing a positive and significant trend from the 2nd year onwards. In the results of the heterogeneous model, we see that the countries with the most statistically significant results are: Portugal, Spain, France, and Italy. In these cases, the results reflect statistical significance in the responses of the Gini Index, both to an inflation shock and to an increase in public debt. To date, this work is pioneer, as the relationship between these variables has never been empirically explored, namely in a context of time-series analysis.



**Keywords:** Gini coefficient, Income inequality, Public debt, Inflation rate, Panel VAR, Global VAR

**JEL Code:** C32, E17, E21, E32, E60, F34

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CHAPTER 1

# Introduction

Since the beginning of the last century, the world has witnessed three major economic events, the 2001 dot-com bubble, the Global Financial Crisis, and the current Covid-19 crisis. Additionally, in Europe, we have witnessed a Sovereign Debt Crisis in 2011 that accentuated the reflection on the unsustainable path of public debt. The impact of inequality in the instability of the economic system and, thus, contributing to these events, have prompted a discussion about the place of inequality in macroeconomics (Botta *et al.*, 2021).

Hence, there are three stylized effects in the current macroeconomic context, extensively discussed in the literature. First, the level of income and wealth inequality has increased, in the last two decades, hampering the intergenerational mobility. Second, the level of public indebtedness within countries grew extensively, constituting an element of instability for economic decisions. Lastly, the inflation rate has evolved modestly in recent decades, although the expansion of monetary policy. In fact, there have been records of temporary increases due to the ultra-expansion of monetary policy, but this effect has been short-lived.

In the present moment, this conduit has appeared as an essential path to explore in macroeconomics. The pandemic crisis brought to closer attention the higher level of income inequality, reflected by the ability of the different income classes to bear with this economic shock. In a moment, where governments increased the public debt levels to incur in an expansion of fiscal policy to minimize the economic shock. The combination of these factors led, in recent months, to sudden rises of inflation rate that promoted higher instability and uncertainty regarding central banking policies.

Therefore, we consider that, understanding the dynamic relationship between these variables is, presently, of utmost importance. For this, we propose a Panel VAR model, using yearly data from 1980 to 2019 for computing homogeneous responses to interchangeable shocks to these variables. Thus, this research constitutes a two-fold contribution to the literature. First, the study of the interchangeable interactions between inflation, public debt, and income inequality, which, as far as it is known, it has never been conducted. In addition to this, the usage of a Panel VAR model, which is a Vector Autoregressive (VAR) process, thus, focusing on a data-drive approach to clarify these dynamic relationships.

However, the heterogeneity of the different economic structures can constitute an essential element for this study, thus, it is briefly presented a Global VAR model (GVAR). The GVAR

model was originally presented as a methodology for studying spatial propagation of a shock, but some authors (Dees *et al.* (2007)), have advocated in favor of this method to ensure that the heterogeneous economic structures are respected in Vector Autoregressive processes. Thus, in this case we present this model as a different estimation process to test the results of the Panel VAR, treating Japan, US and UK as closed-economies, while the European countries enter the model as small-open economies.

The main motivation of this study is the gap found in the literature, mainly regarding the interactions between income inequality, public debt, and inflation rate. In the literature, this research has, only, been explored theoretically, missing an empirical representation that testifies the mechanisms that governed past conclusions.

The findings of this research, in relation to the homogeneous panel VAR model, illustrate that an increase in income inequality decreases public debt until the 5th period, while the response of inflation rate is non-significant. A positive shock in the change of public debt, diminishes income inequality in the 1st period, but it tends to increase income inequality in the 2nd period until the 4th period. The response of inflation rate is negative until the 3rd year, loosing statistical significance for the remaining periods. Finally, a shock in inflation rate decreases public debt in the year when the shock is introduced, leading to a positive variation of public debt accumulation from the 2nd year until the 4th year. The response of the change in income inequality is negative until the 2nd period, where, afterwards, the response is positive until the 7th period.

In relation to the heterogeneous model, thus, the GVAR model, the results present different interactions. In the case of Portugal, we observe that a positive shock in income inequality increases the level of public debt, while France showcases the opposite, a positive shock in income inequality decreases the change of public debt. In the case of a positive shock to income inequality, we see that inflation rate in Spain, Portugal, and Italy reacts negatively. Finally, when a shock occurs in the inflation rate, Germany, Spain, and Finland's income inequality decreases.

In conclusion, this work is structured as following: chapter 2 reviews the literature regarding the intertwined relationship between income inequality, public debt and inflation rate; chapter 3 presents the representation of our Panel VAR model; chapter 4 contains the data and the step-by-step model estimation process; chapter 5 presents the empirical results from the PVAR; chapter 6 tests for robustness checks in the PVAR setup and presents the results from the heterogeneous GVAR model; finally, chapter 7 concludes this dissertation.

CHAPTER 2

# Literature Review

## 2.1. Income and Wealth Inequality — Macroeconomic Implications

The macroeconomic research concerning income and wealth inequality has grown significantly in the last years. Hence, giving an overview on what is defined as income and wealth inequality is of utmost importance, as well as, introducing some studies that have assessed the implications of income disparities.

Inequality is defined as the differences in access or control of economic resources (Van Kerm and Jenkins, 2009). Here, we will focus, mainly, on income inequality which is defined as a flow variable, measuring the amounts of goods and services that are distributed each year (Piketty and Saez, 2014), and wealth inequality which represents a stock variable, measuring the differences between households' holdings of assets and liabilities (Zucman, 2019). Additionally, one should include the definition of income mobility (Jäntti and Jenkins, 2015) which defines the ability for a person, or a generation, to ascend on the social ladder.

In recent years, it is possible to witness an increase in inequalities and the compromising of income mobility (OECD, 2015). In respect to the causes of the increasing levels of inequalities, several authors have emphasized as arguments: the technological progress (Acemoglu, 1999; Galor and Moav, 2000), globalization of trade (Feenstra and Hanson, 2003; Stiglitz, 2012), and financialization (Stockhammer, 2013; Piketty and Saez, 2014). Technological progress affects the demand for skilled labor, increasing the income gap between skilled and unskilled labor (Galor and Moav, 2000) which is, also, dependent on the structure of production conducted by firms (Acemoglu, 1999)[1]. The globalization of trade hypotheses, reflects that as the world becomes more interconnected, the capital and production flow became allocated in more competitive economies, which induced a process of labor-savings techniques and advancements of offshoring production, leading to downward pressure on wages in economies, mainly in unskilled labor. The financialization argument relates to the increased importance of finance for economic growth and how the outplay of this transformation led to the liberalization of financial markets, which have induced speculative bubbles, the introduction of complex products, and risk-taking of the banking sector (Reinhart and Rogoff, 2009; Stiglitz, 2012; Stockhammer, 2013; Piketty and Saez, 2014).

[1] Acemoglu (1999) has assessed the difference in income inequality between the US and the EU. Presenting as an interesting conclusion that income inequality is related to the form of production of US firms that are more dependent on skilled labor. Whereas EU firms are more dependent on the adaptation of capital forms of production.

The most explored topic in terms of macroeconomic implications of the income distribution has focused on the relationship of the latter with growth (Alesina and Rodrik, 1994; Perotti, 1996; Alesina and Perotti, 1996a; Barro, 2000; Ostry *et al.*, 2014). Additionally, some studies have shed light on the interdependence between income distribution and investments (Alesina and Perotti, 1996a). However, in recent years, the focus has shifted towards the effects of income distribution on economic fluctuations and the appearance of crisis (Stiglitz, 2012; Stockhammer, 2013), as well as, the interplay between inequality and finance (Botta *et al.*, 2021).

Alesina and Rodrik (1994), have demonstrated that wealth distribution shapes the political pressure in favor of redistributive policy. Thus, the turning point is the endowment of the median voter[2]. The explanation implies that if the median voter is poorly endowed, then he/she will prefer a higher level of capital tax rate favoring a higher redistribution policy at the expense of public investment, pressuring economic growth. Concerning this, the impact of income distribution on private investments follows a similar mechanism (see Alesina and Perotti, 1996b), when median voter is poorly endowed the level of investments is decreased by the political pressure. In this regard, Barro (2000) has illustrated, relying on a panel data for 100 countries, that economic growth in rich countries is not influenced by the level of the Gini Index, although for poorer economies, the level of the Gini Index is a determinant for growth, due to a higher level of credit market restrictions. The author has found the emergence of the Kuznets curve, whereby inequality increases due to a slow development of the economy or given the introduction of structural processes which, once stagnated, will lead to a downward trend on inequality[3]. An argument that implies that the rising levels of inequality is, in fact, a macroeconomic process (Galbraith, 2007).

### 2.2. Public Debt Dynamics and Sustainability

The difficulty of defining public debt sustainability constitutes a crucial element in the literature. The broader agreement defines public debt sustainability as the ability of the government to honor its current and future financial obligations (Abbas *et al.*, 2019). Additionally, we need to define public debt. In this regard, public debt is a financial claim that requires the payment of interest and/or principal by the public sector, which englobes the general government entities and social security entities. In more expansive views, an inclusion should be made to incorporate public corporations. In this case, we must exclude public corporations in order to capture the idea of debt policy management of governments and its effects on economic inequalities (Abbas *et al.*, 2019; IMF, 2020).

[2]The median voter theorem relates to the preferences of voters given the voter's income and wealth (see Cukierman and Meltzer, 1989).

[3]Kuznets (1955) argued that a structural process that enhances inequality is the urbanization process and technological progress. This is viewed as a macroeconomic process given that it occurs equally to all countries, although there are some differences in the adjustment period.

In the literature strand, a discussion has been held concerning the importance of public debt for macroeconomic conditions, and, thus, the usage of this instrument for fiscal policy. Barro (1974), following the work of David Ricardo[4], discussed the concept of Ricardian Equivalence, prompting the argument that debt is irrelevant for fiscal policy, given that the rise of public debt is absorbed by the households' expectations of an increase in future taxes. Hence, households save in the moment of the debt rise, in order to comply with the increase in future taxes. However, it is believed that savings patterns are heterogeneous and the short-run effects of a debt policy can be relevant for counter-cyclical policies (Elmendorf and Mankiw, 1999). The dynamic process of this argument is based on the process of fiscal policy spending or tax cuts (financed by debt), which increases disposable income and favors consumption. A dynamically inefficient[5] economy due to a crisis, low-interest rates, or an increase in precautionary savings can benefit from an increase in consumption, which is positively associated with economic growth in the short-run (Blanchard, 2019). Blanchard and Perotti (2002) have demonstrated this effect, through an SVAR approach using US quarterly data, where private investment was crowded-out by a rise in government expenditures and, the level of consumption was crowded-in. However, the debt accumulation proposition holds that holding debt can be detrimental for economic growth when the level of public savings is depressed, and private savings are not capable of compensating for this decrease. This effect will diminish the level of investments by the increase of interest rates (Diamond, 1965). Antunes and Ercolani (2020), using an incomplete-markets model with borrowing constraints, have demonstrated that debt-financed fiscal policy tightens borrowing constraints through the increase of the interest rate and deleverages households, increasing precautionary savings.

Regarding the effects of public debt, several literature studies have emphasized the detrimental effects of public debt. An influential paper by Reinhart and Rogoff (2010) using data for twenty advanced countries over 1946-2009 showed, using GDP growth for different levels of public debt, that average and median growth is substantially lower when public debt surpasses 90% of GDP. Related to this, Woo and Kumar (2015) using two approaches, panel data regression, and GMM, have shown that subsequent growth is conditioned by the initial debt level. Stating that a 10 p.p increase in initial debt, leads to a decrease of 0.2 p.p on real *per Capita* GDP. Mauro and Zilinsky (2016) have found that permanent growth slowdown occurs due to the use of expansionary fiscal policy in moments of temporary slowdown, because the temporary slowdown is misunderstood as a structural problem. On an opposing view, McCausland and Theodossiou (2015) have conducted a panel data regression for 11 OECD countries within a

[4]See *The Principles of Political Economy and Taxation* (1821), Chapter XVII by David Ricardo. For a modern review of this concept, see Abel (1991).

[5]Dynamic efficiency represents a situation where real interest rates are lower than economic growth (for a detailed explanation, see Elmendorf and Mankiw, 1999; Blanchard, 2019).

period from 1811 to 2011, to show that government expenditures in public investments are a significant factor for reducing the level of debt in long-term.

Regarding the effects of public debt on investment and fiscal multipliers, one must include the work of Croce *et al.* (2019). The author found that government debt increases the capital cost, which has a negative and significant impact on R&D-intensive firms. However, this proposition is rejected by Huang *et al.* (2018), where they showed that government debt boosts investment for all firms, although less for credit-constrained firms. Afonso and Leal (2019), focusing on European Countries with higher levels of debt, have demonstrated that fiscal multipliers through the increase of government spending resulted in a positive effect on output. These fiscal multipliers have shown higher values for countries in situations of higher levels of public debt, recessions, and having positive output gaps. For this, the author has conducted an SVAR analysis introducing a recursive identification[6] process. They found that tax multipliers present a negative effect on output, hence, arguing against the austerity measures taken in the sprouted European Debt Crisis (Mendoza and Ostry, 2008).

### 2.3. Literature on the links between Public Debt and Inequality

Henceforth, understanding the relationship between public debt and inequality constitutes an unexplored territory in the literature. In recent years, a closer look at the effects of income and wealth inequality combined with the rise of public debt, has prompted some researchers to understand the dynamics between this association. Hence, the core of this issue began with the introduction of Berg and Sachs (1988) work on the structural factors of debt rescheduling in less developed countries. Berg and Sachs (1988), although, concentrating on external debt, presented an empirical paper to assess the effects of income distribution variables (income inequality, the share of the agricultural sector, and the level of GDP per capita) and the degree of openness of the economy in order to estimate the probability of debt rescheduling. For this, the authors have employed a cross-section *probit model* for a sample of 35 countries throughout 1977-1985. They identified income inequality as a principal component of the persistence of debt rescheduling. The mechanism that guides this result is the process of political and social instability that is augmented by income inequality, undermining the credibility of political institutions.

Their work was followed by a divided strand of literature, where some authors have argued that public debt can be a determinant factor of inequality disparities. Whereas the alternative argues that inequalities of income and wealth have played a critical role in the rising levels of public debt.

[6]The recursive identification process used in Afonso and Leal (2019) was the Cholesky Decomposition, where the stochastic shock is introduced through "stages".

### 2.3.1. Public Debt as a Source of Inequality

The reasoning about the effects of public debt as a source of inequality relates to the interest-bearing argument (Mankiw, 2000), households capital constraints (Michel and Pestieau, 1999, 2005), the crowding-out effect of private capital (Maebayashi and Konishi, 2019), and the savings rate implication (Borissov and Kalk, 2020).

Mankiw (2000) began his assessment with the rejection of the two canonical models (Barro-Ramsey Model and Diamond-Samuelson Model). This rejection is based on the, interesting proposition, that households' consumption levels are more correlated with current income[7] than what economic theory suggests. In addition to this, the author emphasizes the importance of bequests for wealth accumulation and, in the same respect, he notes that the lowest income group deciles have a total net worth of 900$ (including house credit), a value which is vastly dispaired in comparison with higher income groups. Hence, he purposes a heterogeneous fiscal policy model incorporating two sets of households: "spenders" and "savers". In this regard, "spenders" reflects the low-income households that fail to smooth consumption[8], while "savers" are higher-income households that are capable of smoothing consumption, generation after generation. In a theoretical model, the author presented that, government debt increases steady-state inequality, arguing that the issuance of public debt resolves in an increase of taxes to finance the rise of interest-payments. Subsequently, the tax increase will fall on both households, but the effects, as already mentioned, are more upsetting for low-income households, which suffer from consumption smoothing restrictions. Whereas, "savers" will behold a small decrease of disposable income in favor of holding the issued bonds, which will translate into interest-bearing assets, fostering their wealth accumulation and bequests position. In a similar work, Michel and Pestieau (1999, 2005) employed a heterogeneous overlapping generations model with altruistic and non-altruistic agents. Thus, following the same approach as Mankiw, but in this case, the altruistic component relates to the importance of leaving bequests for future generations. However, here, the authors expanded their definition to emphasize that altruism corresponds with the capability of incurring a high level of income. They've reached a similar conclusion, which is that an increase of public debt induces a short-run benefit for "non-altruistic" agents but, in the long run, benefits will be held by "altruistic" agents by the same redistribution process from constrained households, as evidenced by Mankiw.

The main concern about the rise of public debt is the decrease of capital in the steady-state, the denominated crowding-out effect of capital. The dynamic of public debt compels a concern about the increasing level of liquidity in the economy. An expansionary policy results in a higher degree of private consumption, which leads to a decrease in private investment, thus,

[7]For a detailed explanation, see Mankiw (2000) and the referenced papers.
[8]Consumption smoothing relates to the balance between household's spending and saving for life-cycle phases (see Morduch, 1995).

leading to an increase in interest rates. Incidentally, the works of Mankiw (2000) and Michel and Pestieau (1999, 2005) constitute an important contribution in these regards. Both authors, advocate that the long-run marginal product of capital[9] is subject to the rate of preferences of "savers"/"altruistic" agents. The authors conclude that the increased level of savings, in response to the upwards trend of the interest rate, constitutes a neutral effect of public debt in the crowding-out argument.

Regarding this mechanism, the work of Maebayashi and Konishi (2019) establishes an improved enhancement. Assessing the steady-state path of debt sustainability, the author found that a condition to sustain a saddle-path of debt is a higher level of inequality. The work sheds light on the dynamics of capital crowding-out, tax burden effect, and public debt. Reflecting that a requirement for the sustainability of debt in an unequal economy with higher levels of public debt is a higher degree of inequality, which holds that higher-income households are capable of sustaining the level of private capital. He suggested that a low level of inequality in an economy with an unsustainable path, augments the crowding-out effect, enhancing the importance of bequests and leading to a constant increase of inequality. A similar dynamic is found in Borissov and Kalk (2020), although, the mechanism, here, is "positional concerns", which denotes the social pressure for consumption by agents. The author argues that a higher degree of "positional concerns" leads to a decrease of the savings rate (reducing investments) in favor of a consumption-based economy, that will face a feedback increase in inequality.

Hence, one can argue that the causality of public debt in inequality is mainly reflected in differences in wealth inequality between income groups. It should be expected that government bonds and the interest rate of bonds are principal components (Mankiw, 2000). In the same way, the level of savings, consumption between income groups, and private investment should be recalled as an important dynamic to recognize (Maebayashi and Konishi, 2019; Borissov and Kalk, 2020).

### 2.3.2. Inequality as Determining Factor for Public Debt

Several authors have emphasized the role of income and wealth inequality in the rising levels of public debt. In the core of this issue, concentrating on political-economy models, the works of Azzimonti *et al.* (2014) and Arawatari and Ono (2017) illustrate the recent endeavors in the assumption of inequality as an important constituent of public debt.

Azzimonti *et al.* (2014) estimated the effects of the interconnectedness of financial markets in the rising of public debt, due to the decline in the elasticity of interest rate, given the increased supply of government bonds. In the same way, relates government debt with the income risk of agents, this income risk is positively associated with the increase of debt as the latter serves as

[9]For a better understanding of the relationship between public debt and the marginal product of capital see Reis (2020).

a substitute for private debt. Hence, the increasing income risk leverages the issuance of debt in order to smooth consumption, which is further augmented by the liberalization and easiness of financial markets. For this, the authors have used a theoretical model using as variables, the share of income earned by the top 1%, the ratio of public debt over income, the time horizon of governments debts, and the interest rate of government bonds for a 1-period and 10-period horizon. Arawatari and Ono (2017) computed a political-economy model in order to assess the assumption of the tax smoothing argument. They based their study on the determining factor of elasticity of intertemporal substitution[10] which induces different fiscal policies. Secondly, they provide a cross-country panel data with fixed effects for 34 countries for a period between 1980-2010, where they found that the Gini Index, government expenditure, and the age dependency ratio are significant and positively associated with the increase of general government gross debt. Ultimately, they have analyzed the international behavior between countries in high levels of inequality in comparison to low levels of inequality. Hence, they found that when an elasticity of intertemporal substitution is lower than 1, a low-inequality country combines tight fiscal policy with low accumulation of debt. Whereas, a higher inequality country experiences a loose fiscal policy with high public debt. Thus, with the increase of the share of higher inequality countries, the low-inequality countries reduce their level of debt by lending to those in a higher-unequal position. This result is opposed to the one that Azzimonti *et al.* (2014) provided.

Lastly, Luo (2020) have tested the assumption of Azzimonti *et al.* (2014), mainly the argument that the labor income ratio is positive associated with an increase of general government debt. For this, the author computed an Ordinary-Least Square regression, using as dependent variable the debt-to-GDP ratio, and as regressor variables income inequality (Theil's T Index and the income share of the top 1%), the labor-income ratio, and the capital income ratio[11]. The regression also included, control variables such as potential GDP per capita, the degree of trade openness and the share of the population between 15 and 65 years. He found that the first two measures of income inequality are non-significant, while the labor and capital income ratio are significant. The labor income ratio decreases government debt, while the capital income ratio increases government debt. This effect occurs due to political support for more redistribution when the capital income is skewed to the right side of the capital inequality distribution of incomes. The period of his analysis was 1970-2010 for OECD countries. The author also did a robustness test for causality using Instrumental Variables, finding similar results.

Hence, one can argue that the causality of inequality in public debt is, manly, reflected in the differences in income inequality and income risk between income groups. It should be expected

[10]The elasticity of intertemporal substitution is defined by the change in current consumption due to a change in the real interest rates (see Arawatari and Ono 2017).

[11]The labor income ratio and capital income ratio define the mean-to-median labor and capital income (see Cukierman and Meltzer, 1989; Luo, 2020).

that the labor and capital income ratio, the age dependency ratio, the Gini Index and the income share of the 1% are principal components for the level of public debt in a country (Azzimonti *et al.*, 2014; Luo, 2020). Whereas, the level of elasticity of interest rates and intertemporal substitution compels an important dynamic for the increase of public debt globally (Azzimonti *et al.*, 2014; Arawatari and Ono, 2017). The latter being a principal dynamic of fiscal policy intervention that emphasizes the non-Ricardian Equivalence argument of public debt.

### 2.3.3. The Relation between Fiscal Policy and Inequality

A principal component of the accumulation of debt is fiscal policy intervention. The fiscal policy instruments relate to the government budget balance, which is defined as a flow variable that measures the differences between government expenditures and revenues. The accumulation of budget deficits is what gives rise to the level of public debt. Considering this, fiscal policy intervention is, in some degree, affected by the level of inequality. It is believed that inequality rises political fragmentation, which tends to favor higher levels of redistribution (Meltzer and Richard, 1981; Alesina and Rodrik, 1994), which decreases the level of private investments (Alesina and Perotti, 1996a). In the same way, higher level of inequalities restrains the government's aptitude for achieving a balanced government budget (Larch, 2012), due to the constraint for increasing taxation (Aizenman and Jinjarak, 2012; Islam *et al.*, 2018). Thus, contributing for the accumulation of debt in recent years.

Hence, a question regarding the effectiveness of fiscal policy due to different stages of inequality arises. This question explores the government's ability to manage short-term fluctuations that will affect the level of public debt.

Regarding the effects of income inequality on the effectiveness of fiscal policy, one must begin by the relation of income distribution and tax-base collection (Aizenman and Jinjarak, 2012; Islam *et al.*, 2018). Aizenman and Jinjarak (2012) employed a two-stage least square model using a collection of data from 50 countries from 2007 to 2011, in order to test how sovereignty risk is conditioned by the ability to tax, which is dependent on the level of the Gini Index. They found that the Gini Index decreased the tax-collection base, which increased the sovereign spread. In a more detailed work, Islam *et al.* (2018) used an instrumental variable approach, for the same purpose. They've used as instrumental variables the 5-year lagged values of income inequality and unionization for a time-period between 1810-2011. The data compels values for 21 high-income OECD countries, where they use inequality measures (pre-transfer market Gini Coefficient and pre-tax top 10% income share), tax revenue-to-GDP ratio, union memberships, trade openness (ratio of imports to GDP), real GDP *per capita* and a democratic categorical variable. As regressions instruments, the authors have used Pooled OLS and the combination of an instrumental variable identification strategy with a 2-Stage-Least-Square model, where the

dependent variable was the income tax-GDP ratio. Whereas, they found that both measures of income inequality appear statistically significant and negatively associated with the ratio of income tax. In the same respect, Larch (2012) assessing the impact of income inequality on fiscal performance for 30 countries, found that income inequality solely is not significant, but softens the impact of economic growth for the fiscal budget. This is evident, when the authors paired the Gini Coefficient with economic growth and political manifestations when computing a panel data with random and fixed effects.

In respect to the effects of inequality in fiscal multipliers[12], Brinca *et al.* (2016) constitute an important contribution. the authors assessed the implications of wealth distribution in response to an expansionary fiscal policy. The authors computed a Structural Vector Autoregression model (SVAR) for a total of 15 OECD countries. Firstly, in an Ordinary-Least Square model, the author presented that the wealth Gini Index and the capital-output ratio are positively associated with fiscal multipliers, noting that one standard deviation in the wealth Gini index increased the level of multipliers by 17%. For these results, the authors have as variables: the percentage of households with borrowing constraints, the level of capital-to-output ratio, the interest rate, tax level, and tax progressivity. Concluding that the determining factor for the increase of fiscal multipliers is the percentage of households facing a borrowing constraint and an increase of wealth Gini coefficient. This result is complemented by the work of Obst *et al.* (2020), computing a short-run empirical post-Kaleckian Model for 15 European countries, where the authors assessed empirically, that a fiscal expansion increases consumption and private investments. Additionally, they have considered an introduction of a progressive tax system[13]. The authors have found that a progressive tax system induces an increase in consumption outweighing the decrease in private investment, which, ultimately, contributes to an increase of output in most of the 15 countries.

Hence, on the core of this issue, one should encapsulate fiscal policy variables in order to envision the dynamic of public debt. The flow variable of government budget is the main mechanism that leads to the fluctuation of the levels of public debt. Thus, it is expected that the budget balance, government expenditures on transfers and social schemes, as the inclusion of tax-base collection (capital and labor income tax-to-GDP), and estimation of fiscal multipliers in relation to Gini Index, should be recalled as main determinants to capture the dynamics between public debt and inequalities.

[12]Fiscal multipliers denominates the effect on output from an intervention of fiscal policy.
[13]Obst *et al.* (2020) define the redistribution policy as a decrease of 1% of labor income in favor of a 1% increase of tax on capital income.

### 2.4. Inflation, Inequality and Debt Linkage Literature

In the middle of the interplay between income inequality and public debt, lays the price dynamics that affects policy decisions. The price dynamics within an economy is given by the inflation rate. Inflation rate is a crucial element for monetary policy setting, as well as for fiscal policy decisions. Hence, the distributional effects of the inflation rate bears costs for inequality (Camera and Chien, 2014). In the same way, it weights largely on government's decision to issue public debt. Theoretically, both dynamics can induce an inflationary process due to an increase of the aggregate demand accompanied by an increase in liquidity for a rigid level of supply. Thus, it is necessary to introduce some recent research concerning the linkage between inflation and both dynamics.

In respect to the distributional effects of an inflationary process, the mainstream view considers inflation to be "the cruelest tax" (Binder, 2019). However, this relationship has been ambiguous in the literature strand. The mainstream hypothesis is that inflation increases inequality, given that low-income households hold more cash as a share of assets and are more prone to contracts that are less indexed to inflation (Erosa and Ventura, 2002).While, richer households are more invested in capital market, holding assets that are more protected from inflationary processes. This effect can be, also, portrayed through the differences between productive sectors, where richer households are more capable of obtaining income increases due to being in a more productive sector (Albanesi, 2007; Bulir, 2001). However, an opposing effect can occur by the erosion of debt held by households (Doepke and Schneider, 2006), through the reduction of real interest rates that low-income households pay on mortgage debt, thus, reducing the amounts of mortgage payments (Budd and Seiders, 1971; Hedlund, 2019) and, increasing the value of houses (Colciago *et al.*, 2019)[14]. In the last two decades, this opposing effect appears to be proven, given that Binder (2019) has found that, within this period, the correlation between income inequality and inflation has been negative[15]. This contrasts with previous studies that have found a positive correlation between inequality and inflation (Albanesi, 2007; Bulir, 2001; Romer and Romer, 1998).

Regarding the relationship between public debt and inflation, there appears to be a consolidated opinion about the positive effect of public debt on inflationary processes in the long run (Beetsma and van der Ploeg, 1996; Bildirici and Ersin, 2007; Sargent and Wallace, 1981; Taghavi, 2001). Taghavi (2001) examined the adverse effect of public debt in main macroeconomic aggregates (inflation, investment, and growth) for the European Economies between 1970 and 1997, where using a VAR model, concluded that the rise of public debt increases the

[14]Colciago *et al.* (2019), have found that the more indebted households are the middle-three quartiles

[15]Binder (2019), have presented a cross-sectional regression analysis, where the authors have found that there is a negative correlation of -0.13 between income inequality and inflation, mainly in the European continent, for the period 1991 to 2017. Where before this period, the correlation was positive (0.31). Therefore, the author tested the argument of the Central Bank Independence, with an OLS Regression, which has demonstrated positive significance for this change.

inflation rate in subsequent years. Sargent and Wallace (1981) demonstrated, using an OLS Regression and VAR for 71 countries from 1963 to 2004, that the relationship between public debt and inflation in positive for developing countries, but is not observable for developed countries. Bildirici and Ersin (2007), using a FMOLS and VEC Model, for the period of 1980 to 2004, showed that inflation rate increases with the rising costs of debt expenses. Beetsma and van der Ploeg (1996) in a political economic model, studied the effects of inequality in inflation and public debt. The authors have found that more unequal societies give rise to political conflicts in favor of populist measures of fiscal policy, which are financed by increases in public debt.

Additionally, this inflationary process tends to decrease the level of public debt (Binder *et al.*, 2014; Reinhart and Sbrancia, 2015), which tends to be larger if combined with financial repression. This argument has grown extensively in the literature. Binder *et al.* (2014) studied the effects of low inflation and higher inflation on public debt for the G7 countries, finding that a low level of inflation would increase the level of public debt by 5 percentage points, on average, where a higher inflation rate would result in a decrease of public debt, accounting for the full Fisher Effect, by 11 percentage points. In the same way, a similar result was found by Reinhart and Sbrancia (2015), where the authors have found that combining financial repression and higher levels of inflation rate is the most effective way to reduce public debt.

Hence, it should be expected that inflation rate will have a negative effect on public debt, following the argument of debt erosion, while the rising levels of public debt induces some credit market risk, rising the costs of debt service that pressures the inflationary process in the economy. Equally, rising levels of public debt, according to literature, benefit in the short-run the low-income households, alleviating the income inequality gap, while the decreasing levels of income inequality can, further enhance inflationary process, through the increased level of demand within the economy.

### 2.5. Literature on Panel VAR

Panel Vector Autoregression is increasingly becoming a workhorse on applied macroeconoics. The closer relationship between economies, prompted economists to search for empirical approaches that focus on multivariate analysis in a multi-country setting. The PVAR approach follows a Vector Autoregression (VAR) Process, originated by Sims (1980), which constitutes a data-driven empirical model, avoiding theoretical biases, as evidenced by Canova and Ciccarelli (2013).

The introduction of the Panel VAR model, introduced by Holtz-Eakin *et al.* (1988), allows for a cross-sectional analysis in a panel data structure, where observations are heterogeneous while preserving time-series information.Initially, this model assumed a sectoral homogeneity

between observations, which have evolved to incorporate cross-sectional dynamic heterogeneity, able to capture static and dynamic interdependencies (Abrigo and Love, 2016).

In economics research, this approach has been used to study the closeness of real business cycles (Canova and Paustian, 2007), evaluating the transmission of real, financial and monetary shocks Canova and Ciccarelli (2013), and to examine dynamic interactions.

Related to the business cycle research, Canova (2005) and Rebucci (2010) use Panel VAR models to investigate whether originated external shocks affect the variability of domestic variables. Finding that the US monetary shocks and temporary external shocks impacted the medium-and-long term variability of growth rates in the country at analysis. In the same way, Lof and Malinen (2014) estimated a PVAR model to determine the effect of sovereign debt on growth and found a non-significant impact of debt on growth.

Regarding shocks transmission investigation, PVAR models have been used to investigate common factors and spillovers between financial and real economic linkages. Ciccarelli *et al.* (2016) when examining the transmissions of shocks across units, found that country-specific shocks remain important in the heterogeneous behavior in observed countries. Attinasi and Metelli (2017) study the effects of fiscal consolidation on debt-to-GDP ratio of 11 European countries, finding that a consolidation via increase in government revenues results in a self-defeating austerity, where via government spending the shock will eventually revert to a pre-shock level.

As far as it is known, panel VAR has been employed to study income inequality interdependencies, in a panel data that envisions the understanding of common factors, while assuming some heterogeneity. Aksoy *et al.* (2019) studied demographic effects on medium-term trends of key macroeconomic variables, using 21 OECD countries, finding a negative relationship between aging population and output growth as in real interest rates. Jeong and Kim (2018) used the panel VAR approach to test the theoretical argument regarding financial development, economic growth, and income inequality. The author found that financial deepening, by increasing the level of private credit, reduced output growth in favor of increases in stock market returns.

In relation to our work, Hailemariam *et al.* (2021) constitutes the most related work in terms of empirical representation. The author uses a Panel VAR model, with an estimation process of forward orthogonal deviation, to determine the long-run effects of economic, social and political variables for changes in Gini coefficient. In our case, the intention of this research is to expand this empirical representation to find macroeconomic interactions in a multi-country setting environment.

CHAPTER 3

# Methodology

## 3.1. Panel VAR

The PVAR model was firstly introduced by Holtz-Eakin *et al.* (1988) in a seminal paper that envisioned the study of the dynamic interdependencies between wages and hours worked. Since then, this empirical approach has been a workhorse approach for testing economic interdependences. The argument for selecting this approach, relates to the advantage of assuming a minimal set of restrictions, thus, representing a data-driven approach.

The PVAR model follows the same structure of the VAR model, where each variable enters the model endogenously, leading to a homogeneous approach to account for dynamic interdependencies in a cross-sectional data.

Thus, the empirical representation of a second order Panel VAR, can be represented as follows:

$$y_{i,t} = \delta_t + \varphi_i + A_1 Y_{t-1} + A_2 Y_{t-2} + e_{i,t} \quad i = 1, \ldots, N \quad t = 1, \ldots, T \tag{1}$$

In Eq.(1), we have that $Y_t$ is the stacked version of $y_{i,t}$ that compels the $G \times 1$ vector of endogenous variables that enter the model. The $\varphi_i$ comprehends a $G \times 1$ vector of time-invariant state fixed effects, while $\delta_t$ represents time effects that are not observed. The $e_{i,t}$ is a $G \times 1$ vector of random unit disturbances, and the $A_p$ represents the matrix of coefficient to be estimated. The $e_{i,t}$ represents the vector of error terms, which are independently and identically distributed with $\sum_{i,i}$ covariance matrices.

In our case, we will use the generalized method of moments (GMM)-system as a way to calculate consistent parameters (Abrigo and Love, 2016). The component of fixed effects, although accounting for individual characteristics between units, induces biased estimations which has a significant hamper effect on our data. The GMM provides two transformations regarding the introduction of the variables: first-difference estimation, where the first-lag length of each variable is used in the estimation for eliminating panel fixed effects (Anderson and Hsiao, 1982), and forward orthogonal deviations (Arellano and Bover, 1995), where past observations are preserved as important instruments, thus using the average of all future observations in order to subtract coefficients on the right-side of the panel, eliminating country fixed-effects. Hence, our

model will employ a forward orthogonal deviation transformation, the so-called "Helmet Procedure", as stated by Abrigo and Love (2016), "instead of using deviations from past realizations, it subtracts the average of all future observations, thereby minimizing data loss". Thus, this process allows us to preserve data, while removing fixed unobserved effects. Below, we provide the mathematical representation of this transformation on an endogenous variable, $y_{i,t}$ :

$$\bar{\bar{y}}_{i,t} = (y_{i,t} - \bar{y}_{i,t})\sqrt{\frac{T_{i,t}}{T_{i,t}+1}} \tag{2}$$

$T_{i,t}$ is the number of available future observations in our sample for a panel $i$ at a time $t$. Thus, the orthogonal transformed endogenous variable, $\bar{\bar{y}}_{i,t}$ describes the difference between current observations, $y_{i,t}$, and the average of all future observations $\bar{y}_{i,t}$. Then, applying this transformation to the endogenous variables, reduces the gaps between countries and ensures that past observations are not transformed, enhancing the autoregressive process. Thus, we can rewrite the equation 1 as having no fixed effects:

$$\bar{\bar{Y}}_{i,t} = A_1 \bar{\bar{Y}}_{i,t-1} + A_2 \bar{\bar{Y}}_{i,t-2} + \delta + e_{i,t} \quad i = 1, \ldots, N \quad t = 1, \ldots, T \tag{3}$$

Finally, the panel VAR estimation characterizes two important components: i) the introduction of endogenous variables in lagged form, which accounts for dynamic interdependencies; and ii) the error covariance matrix which is usually correlated between countries, representing the static interdependencies.

In the case of the Impulse Response Functions (IRFs), equation 3 can be rewritten as $B_p \bar{\bar{Y}}_{i,t} = e_{i,t}$, where $B_p = (I_k - A_p)$. Additionally, the $e_{i,t}$ is correlated contemporaneously, which implements a Cholesky Decomposition on $\sum_e = P'P$, where $P$ is a lower triangular matrix that imposes a recursive assembly (Sims, 1980), where the orthogonal disturbances are $P^{-1}e_{i,t} \equiv e_{i,t}$.

CHAPTER 4

# Data and Model Specification

## 4.1. Data

The data used in this study compels a balanced panel data with yearly observations, reaching from 1980 to 2019 for a total of 14 countries (N = 14, T = 40). The choice of the time window reflects data availability, specially regarding income inequality data.

Hence, the model includes three endogenous variables which are: ***pdebt***, representing the general government debt as a percentage of the GDP; ***gini***, indicates the pre-national income Gini coefficient, and, finally, ***inf***, reflecting the inflation rate. The complete description and sources of the variables are showed below:

- General Government Debt as percentage of GDP (***pdebt***) relates to the total stock of debt liabilities issued by the general government as a share of the total production of the economy. It's widely used to measure the level of indebtedness of government and public corporations. See Abbas *et al.* (2019) for further details on debt components. The data source is the Global Debt Database from International Monetary Fund (IMF).
- Gini Coefficient (***gini***) refers to a well-known measure of income inequality which takes values between 0 and 1. Here, 0 indicates perfect equality, whereas 1 indicates perfect inequality. The data refers to the pre-tax national income, which doesn't account for the introduction of subsidies and taxes. Thus, representing the market inequality. The source of this variable was the World Inequality Database, https://wid.world/. In our case, we transformed Gini coefficient by multiplying the variable by 100, in order to better comprehend the changes in the first-difference of the variable.
- Inflation Rate (***infl***) measures the rate at which the price of consumer goods and services change over time. The inclusion of this variable relates to the recent endeavors on understanding the effect of inflation rate in income inequality, namely market inequality. The relationship between inflation and public debt has been studied extensively and can represent a three-way intertwined relationship between monetary preferences, fiscal policies, and inequality. The source is the International Financial Statistics Database retrieved from International Monetary Fund.

In order to do a robustness check, we will use a different variable that represent the same underlying economic interpretations. Hence, as alternative measures for ***gini***, we present the following variable:

- Share of Income of Top 10% Income Earners (***Top_10***) refers to a measure of income inequality that captures the fraction of income is attained by the top income class. It serves the purpose of being an alternative measure for income inequality. The source of this variable is the World Inequality Database.

The list of countries used in the PVAR model are:

| **Countries** | | | |
|---|---|---|---|
| Austria | France | Japan | United Kingdom |
| Belgium | Germany | Netherlands | United States |
| Canada | Greece | Portugal | |
| Finland | Italy | Spain | |

**Table 4.1.** List of countries in the PVAR model

In Table 4.1, we can see the countries that enter the PVAR model. The selection of the countries is based on data availability regarding the Gini coefficient and general government debt (%-to-GDP).

As shown in Table 4.2, there are important considerations to make across the countries in the study. The Gini coefficient presents a standard deviation of 4.87, with a mean value of 45.97 across countries. In the case of ***pdebt***, we can see that there are great disparities between observations, reflecting the high degree of heterogeneity. In the case of ***infl***, we see that the standard deviation is 4.4, for a mean value of 3.68. See Table 4.2 for a complete detail regarding the descriptive statistics. A table of summary statistics grouped by country and year can be found in the Appendix B. The Table B.1 relates to the summary statistics by year. We present this table in steps of 5 years. Moreover, the Table B.2 illustrates the country summary of statistics by country.

Further analysis, will be made using as dependent variables: ***gini***, ***pdebt*** and, ***infl***. The remaining variables will be analyzed in the robustness test subsection.

| Variable | Definition | Mean | SD | Min | Max | N |
|---|---|---|---|---|---|---|
| gini | Gini Coefficient Pre-National Income | 45.97 | 4.87 | 34.14 | 58.87 | 560.00 |
| Top_10 | Share of Income of Top 10% Income Earners | 34.30 | 4.62 | 23.28 | 46.02 | 560.00 |
| pdebt | General Government Debt (% of GDP) | 76.40 | 39.35 | 10.89 | 237.95 | 560.00 |
| infl | Inflation Rate (%) | 3.68 | 4.40 | -1.74 | 28.38 | 560.00 |
| Observations | 560 | | | | | |

**Table 4.2.** Descriptive Statistics of used variables

### 4.2. Model Specification

This subsection intends to explain the necessary preliminary steps required to attain a coherent model. Thus, this section should be viewed as a step-by-step procedure for estimating the Panel VAR Model.

| Variable | Maddala and Wu (1999) | | Pesaran (2007) | | ADF | |
|---|---|---|---|---|---|---|
| | $\chi^2$ | *p-value* | *z* | *p-value* | *z* | *p-value* |
| Gini Pre-national Income | 40.35 | 0.062* | -0.911 | 0.181 | -0.66 | 0.55 |
| General Government Debt (% GDP) | 25.68 | 0.591 | 0.204 | 0.581 | 0.017 | 0.53 |
| Inflation Rate | 173.10 | 0.000*** | -7.003 | 0.000*** | -9.5275 | 0.00*** |

The values presented on this table refer to the Maddala and Wu (1999) and Pesaran (2007) test using lag-length of 1. *, ** and *** indicate the level of significance at the 10%, 5%, and 1%, respectively.

**Table 4.3.** Panel Unit Root Test in Levels, Maddala and Wu (1999), Pesaran (2007) and ADF Test (Choi, 2001)

| Variable (First-Differenced) | Maddala and Wu (1999) | | Pesaran (2007) | | ADF | |
|---|---|---|---|---|---|---|
| | $\chi^2$ | *p-value* | *z* | *p-value* | *z* | *p-value* |
| Gini Pre-national Income | 271.085 | 0.000*** | -11.799 | 0.000*** | -9.68 | 0.00*** |
| General Government Debt (% GDP) | 98.528 | 0.000*** | -5.110 | 0.000*** | -4.93 | 0.00*** |
| Inflation Rate | 173.099 | 0.000*** | -7.340 | 0.000*** | -9.5275 | 0.00*** |

The variables introduced in this test are in first differences. *, ** and *** indicate the level of significance at the 10%, 5%, and 1%, respectively.

**Table 4.4.** Panel Unit Root Test in First Differences, Maddala and Wu (1999), Pesaran (2007)

An important specification to model panel data and autoregressive processes is that the series must be stationary, see Appendix A. A series is weakly stationary when the mean and properties of the covariance of the series doesn't depend on time. In our case, we are considering a panel unit root test, which adds cross-sectional dimension to the properties of the standard time series unit root tests. Since we are introducing cross-sectional dimension to the series, one should focus on two types of unit root tests: cross-sectional independent and cross-sectional dependent.

The difference between these two cases depend on how much the series is influenced by common forces. Hence, in order to account for these differences on the importance of heterogeneity effects and common factors, we use three unit root tests: i) Maddala and Wu (1999) to account for cross-sectional independence; ii) Pesaran (2007) to account for cross-sectional dependence; and, iii) Augmented Dickey-Fuller Test, proposed by (Cheung and Lai, 1995), which serves as a base test in unit root testing. The focus on cross-sectional dependence is to ensure that common factors are taken into account, given that the existence of cross-sectional dependence can result in improper statistical conclusions. Regarding our data, one can assume that countries are dependent on common factors, mainly due to the entrance of eurozone countries and the increasing globalized business cycles. For this, the usage of cross-sectional dependence unit root test, developed by Pesaran (2007) can be an improvement, given that the cross-section averages

of lagged variables and fist-differences of the individual series are considered. In the Table 4.3, we can see that all variables, except for inflation rate, are integrated of order 1, $I(1)$. Hence, Gini Coefficient and Public Debt will be specified in first-differences. Given that, as we can see in Table 4.4, all variables are stationary in first-differences.

| Lag | CD | J | J *p-value* | MBIC | MAIC | MQIC |
|---|---|---|---|---|---|---|
| 1 | 0.914 | 57.902 | 0.000 | -110.11*** | 3.902 | -40.819*** |
| 2 | 0.904 | 25.933 | 0.101*** | -86.073 | -10.067*** | -39.881 |
| Observations: 476 | | No. of panels = 14 | | Ave. of T = 34 | | |

*, ** and *** indicate the level of significance at the 10%, 5%, and 1%, respectively. In the case of the MBIC, MAIC and MQIC, we use *** to illustrate the lowest value.

**Table 4.5.** Optimal Lag Selection for PVAR Model using Andrews and Lu (2001)

The second specification test relates to the selection of lags to be included in the model. In a PVAR model, the selection of lags should balance the arisen of serial correlation and the curse of dimensionality. Serial correlation can hamper the efficiency of the model, given that we are overestimating the lag-effects on observations. The curse of dimensionality implies that estimated parameters weight heavily on the model, due to the over-specification of coefficients in comparison to the number of available observations. Hence, given that we have yearly data for a small time-period ($N = 40$), we can accept a lag-length between 1 and 2.

For the selection of the optimal lag order, we use the Moment and Model Selection Criteria (MMSC) proposed by Andrews and Lu (2001). The test is based on Hansen (1982)'s J Statistic of overidentifying restrictions[1]. Table 4.5, provides the commonly used likelihood-based model-selection criteria, namely the Akaike Criteria Information, Bayesian Information Criteria, and Hannan-Quinn information criteria (AIC, BIC, HQIC). For more detail, see Abrigo and Love (2016). As shown in Table 4.5, we have two possible lag-length scenarios. Regarding the Hansen's J p-value, we see that our model will be better specified as a PVAR(2), where the conclusion is that in a model with lag-length of 2, we fail to reject the null hypotheses of proven overidentification instruments. Thus, one can assume that instruments can impact the variation of the endogenous variables. In this case, we have an overall coefficient of determination (CD) of 90% regarding the variation explained by the model. In regard to the likelihood-based model selection criteria, it's possible to see that the AIC is the smallest for a lag of 2. The AIC overfits the parameters while not considering the number of observations, which, given our sample, can improve our analysis.

Finally, we can see from Figure 4.1 that the stability condition is satisfied for the PVAR model. Stability implies that the introduction of the variables in the model doesn't result in a

[1] Hansen (1982)'s test has the null hypotheses that overidentification restrictions hold. Thus, assuming that our instruments are not weak in impacting the variation of the endogenous variables.

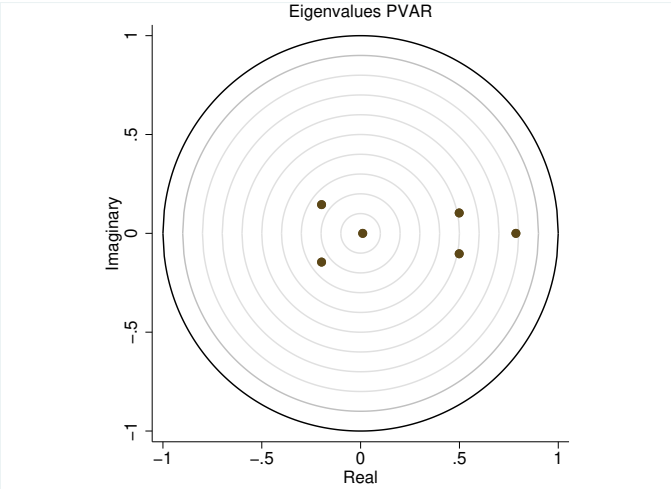


**Figure 4.1.** Graphical Representation of the Eigenvalues

spurious relationship. Lütkepohl (2005), demonstrates that a VAR is sensible to non-stationarity and lag-selection processes, which endangers the statistical significance and responsive behavior, thus indicating that an autoregressive process is stable if all eigenvalues are strictly less than one. This is verified in our model, where all the eigenvalues fall on the hypotheses of interest.

In conclusion, given the importance of the Cholesky Decomposition, our model, in first differences, follows the following structure: public debt, Gini coefficient, and inflation rate. Where, public debt is the most endogenous variable, defined by the fiscal policy, that will compel the redistributive policies that affect income inequality. Whereas, inflation rate results from the interplay of the economic system, and decisions guided by economic agents.

CHAPTER 5

# Results

## 5.1. Granger Causality Tests

The Granger Causality tests provide important information when understanding dynamic relationships. It tests whether the dependent variable is predicted using the past values of the explanatory variables, conditioned by the prior observations of the dependent variable (Granger, 1969). The implementation of this test compels a Wald-type Test applied to panel data, where the null hypotheses represent the null significance of the coefficient on all lags of the endogenous variable, i.e., no Granger causality.

| | Gini | | | Pdebt | | | Infl | |
|---|---|---|---|---|---|---|---|---|
| | $\chi^2$ | *p-value* | | $\chi^2$ | *p-value* | | $\chi^2$ | *p-value* |
| Pdebt | 10.38 | 0.006*** | Gini | 12.29 | 0.042** | Pdebt | 6.47 | 0.039** |
| Inflation | 17.26 | 0.000*** | Inflation | 12.61 | 0.001*** | Gini | 1.95 | 0.37 |
| All | 28.84 | 0.002*** | All | 28.50 | 0.00*** | All | 9.07 | 0.059* |

*, ** and *** indicate the level of significance at the 10%, 5%, and 1%, respectively.

**Table 5.1.** Granger Causality Results

Table 5.1 shows the panel Granger causality tests for the different set of dependent variables. Accordingly, the hypotheses test is whether the coefficients of the lagged values of the variables presented on the bottom panel are jointly zero to explain the values of the dependent variable (presented in the top panel). In this regard, for the Gini coefficient, we can reject the null hypotheses and claim that the lags of Public Debt and Inflation "Granger causes" Gini, such that both variables are important in determining the levels of income inequality within an economy. The same can be said for the public debt equation, where we can reject the null hypotheses at 95% confidence level of non-significance for the explanatory variables, reflecting that the lagged values of Gini and Inflation have a causal relationship in public debt. Finally, regarding the inflation equation, we can reject the null hypotheses for past values of public debt, but we cannot reject regarding the past values of Gini coefficient. However, when testing for the coefficients of all lags of all endogenous variables, we can reject the non-significance hypotheses at the 90% confidence level, which is due to the public debt. Thus, emphasizing that, for monetary settings and change in prices, Gini alone is non-significant, but it can be important when combined with other macroeconomic aggregates.

### 5.2. Impulse Response Functions

In this subsection, we present the graphical representation of the orthogonalized impulse response functions (OIRFs) of an impulse to an identified variable. Figure 5.1 illustrates the OIRFs regarding an impulse to the Gini coefficient. Figure 5.2 and 5.3 illustrates the OIRFs of an impulse on public debt and Inflation rate, respectfully. The grey region shows the 95% confidence interval computed by 200 Monte Carlo simulations.

#### 5.2.1. Shock in Gini Coefficient

As shown in Figure 5.1, the impulse response of the variables to a one standard deviation shock of the Gini coefficient is consistent to the conclusions obtained from the Granger causality test. The response of the inflation rate is not statistically significant, reflecting the rejection of in Granger causality (Table 5.1).

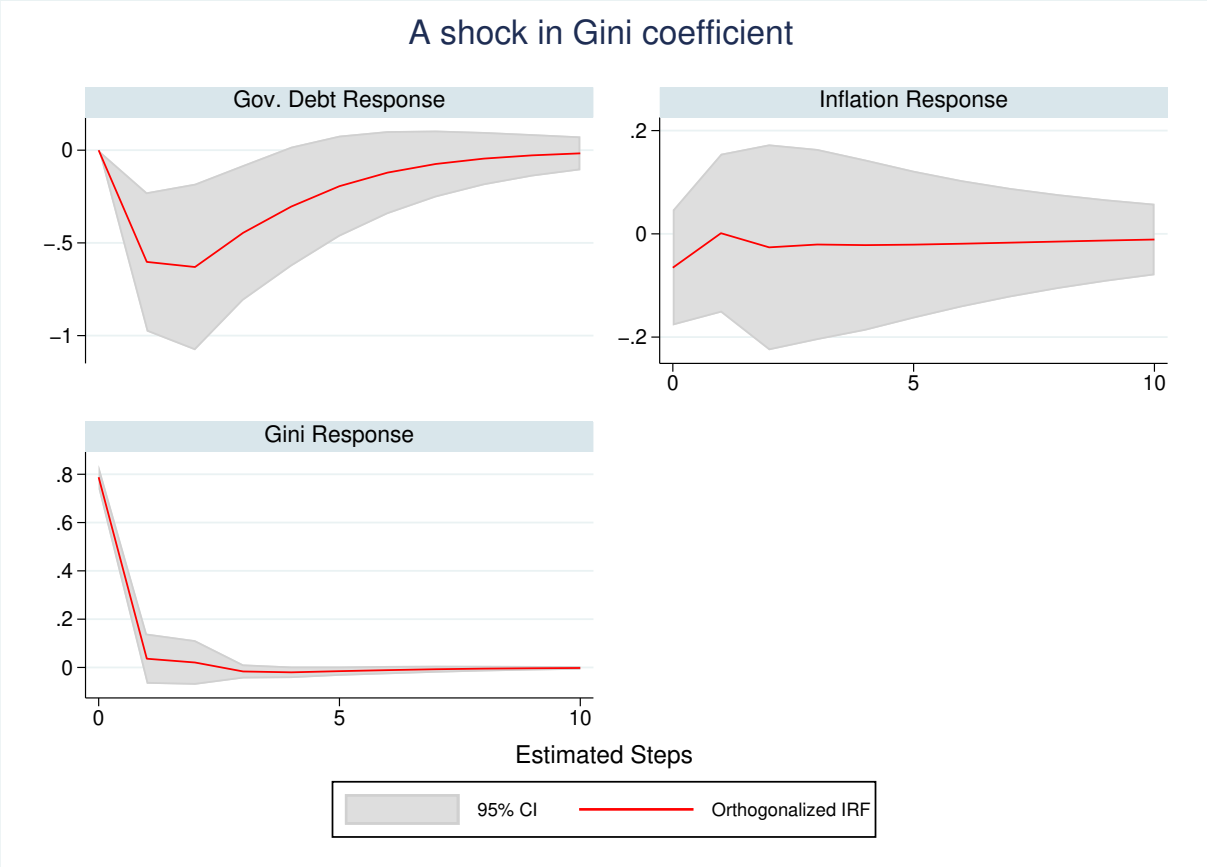


**Figure 5.1.** OIRF of a positive s.d shock in Gini Coefficient

Regarding the response of public debt variation, the shock in Gini coefficient is statistically significant. The response in the change of public debt is negative and short-lived, the response function illustrates that the change in public debt decreases in -0.5% after one year. Thereafter, the response is negative but lower until reaching the 5-step year ahead, where the response loses statistical significance.

As a robustness check, the Gini response after a shock to itself reflects that an increase in Gini coefficient is short-lived and tends to 0 after a period of one year. This indicates that the variation of inequality dissipates over one-period, which is an expected theoretical behavior.

Hence, a positive shock to the change in Gini coefficient leads to a negative response of the change in public debt. Our results corroborate the argument introduced by Maebayashi and Konishi (2019), where the author emphasized that for a superior level of public debt, income inequality can serve as an equilibrium force to stabilize the crowding-out effect of public capital within an economy. The interpretation follows the assumption that wealthier households will sustain the level of capital through the increase of private capital. In addition, the results showcase a null effect in the moment of the shock followed by a decrease in the change of public debt, this promotes the argument introduced by Larch (2012). The author argued that an increase in income inequality promotes a reduction in tax-base collection, which prompts governments to reduce social spending to equal the reduction in government revenues. In conclusion, one can see that income inequality plays an important role in debt sustainability.

### 5.2.2. Shock in Public Debt

In Figure 5.2 we can see the response functions of the variables regarding a positive shock to the change in government debt. Here, we have that a one standard deviation shock to the variation of debt results in a statistically significant response of the first-differencing of Gini coefficient, and inflation rate, thus, confirming the results obtained from the Granger causality tests.

Inflation rate responds negatively to a shock in public debt until the 2nd period, where afterwards it becomes statistically insignificant. This result emphasizes the lower levels of inflation in a period of higher level of indebtedness promoted by an expansion of monetary policies.

The response of Gini coefficient is negative in the moment of the shock. Subsequently, the response is positive until the 3rd period. This indicates that the rise of public debt favors low-income household in the short-run, but it can accentuate the differences of income classes in the medium-term.

The response of debt in a shock to itself it's understandable, given that a positive shock in itself leads to a decreasing positive variation until. The persistence of the response variable occurs until the 4th period.

The results corroborate the economic literature that argues that public debt serves as a tax-smoothing component in fiscal policy, contributing to the reduction of income inequality in the short-run. Although, accounting for a higher degree of inequality in the medium-term given that higher-income households benefit from holding these interest paying assets, while the postponed taxes will fall in greater percentage on low-income households. Barro (1974), Alesina and Rodrik (1994), Mankiw (2000), Michel and Pestieau (1999) and Michel and Pestieau (2005) have showed this interaction in theoretical models. In the short-run, the low-income households

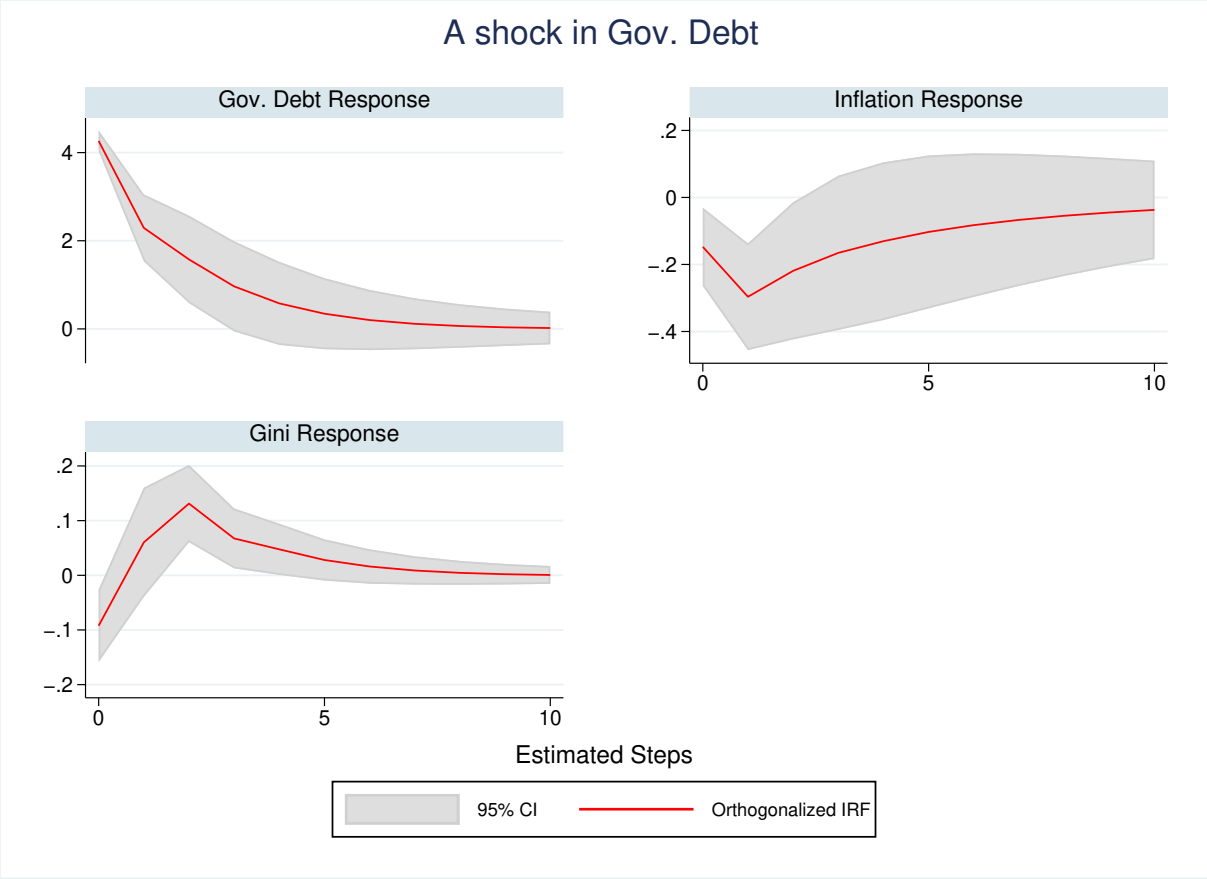


**Figure 5.2.** OIRF of a positive s.d shock in General Government Debt

will benefit from increasing levels of public debt, by the means of higher redistributive policies or tax postponement. This, in turn, will lead to a higher savings rate for higher-income households, specially in governmental assets, and a rise in consumption of lower-income households. Since, the level of consumption increases for a fixed amount of capital, this will propel an increase in the real interest rates within the economy, meaning higher interest payments towards higher-income households. The increases in taxes that finances these payments, further expands the differences in disposable income between income classes, falling in a greater proportion on lower-income households.

In a macroeconomic context of higher levels of indebtedness, this interaction can be expanded by the increase in credit risk, where top income classes will require a premium for holding these assets avoiding governments to incur in default. Our results serve as a valid representation of this interaction.

### 5.2.3. Shock in Inflation

In the figure below, Figure 5.3, we can see that a one standard deviation shock to the inflation rate results in statistically significant responses in Gini coefficient and government debt.

In the case of the public debt response, an increase in the inflation rate results in a short-lived decrease of the change in government debt in the moment of the shock, which, afterwards,

leads to an increase in debt accumulation until the third period. Initially, the variation of debt decreases 0.5%, followed by an increase to near 0.5%. In the case of the Gini, the response is negative until the 2nd period, followed by a positive reaction afterwards, which eventually falls towards 0. The reduction in the first-differencing of Gini is -0.1, followed by an increase in the first-differences of Gini of, about, 0.05 until the 7th period. The reaction of inflation to a shock in itself is more persistence, only, reaching non-significance in the 7th period.


**Figure 5.3.** OIRF of a positive s.d shock in Inflation Rate

Regarding our results, we can see that, in the short-run, inflationary processes can contribute to the reduction of income inequality. Binder (2019)'s work corroborates this relationship by finding that, in recent decades, the correlation between income inequality and inflation has shifted to a negative correlation. The reasoning for this result, perhaps, lies on the erosion of debt argument (Doepke and Schneider, 2006), where low-income households will benefit from the valuation of their homes, decreasing the impact of real interest rates of their debts. In addition to this, it appears that there is an increase in political conflicts for higher wages and social contributions, in order to compel with higher prices, which benefits the low-income classes. In the medium-term, after the initial reaction to the shock, the response of Gini coefficient is positive. The persistence aspect of inflation rate decreases the disposable income of lower-income households, which are more prone to hold cash that, in moments of inflationary processes, lose

value. In this economic environment, richer households are more protected, given that they are able to hold financial assets that benefit from increases in prices. In respect to this, the medium-term response brings to the forefront an additional argument based on the easiness of wage increases in different sectors. Bulir (2001), Erosa and Ventura (2002), and Albanesi (2007) demonstrates that technological-based labor are more able to increase wages compared to non-technological and cyclical sectors.

Regarding the response of public debt, the results are well-expected, given that they go in favor of the consensus view in economic theory. A shock in inflation rate devalues debt in a short-period (0-step), where the denominator of general government debt-to-GDP increases with the valuation of prices. In the current situation, with lower interest rates, the price increase leverages the production of the economy through a price-effect, even if production remains unchanged. Reinhart and Sbrancia (2015), validate this result, emphasizing that there is a role of inflation rate in devaluing debt, although the effects are more pronounced if combined with a financial repression system. After the 2nd period, we see a positive response in the changes of government debt, which indicates the pressure to increase government expenditures if an inflation shock persists.

### 5.2.4. Cumulative OIRFs

In order to assess the long-term effects of the shocks, the Figure 5.4 displays the cumulative orthogonalized impulse response functions for the different shocks. The cumulative OIRFs represent the cumulative sum of the responses up to the corresponding period (estimated steps).

In this case, we can see that the results presented are similar to the ones showcased before. The only cumulative OIRF that showcase a statistical significance in the last estimated step is the response of public debt to a positive shock of Gini coefficient, where an increase in inequality creates a persistent effect on the reduction of public debt.

The remaining statistical significant figures, present medium-term (up to 7 years) of statistically significant responses. Regarding the response of Gini to an inflation positive shock, we can see that there is a negative response (increase in equality) in the short-run, verifying the OIRFs presented before, and, indicating that a change in prices has, only, a short-run effect on the change of Gini coefficient. In the bottom left panel, we can see that the response of public debt variation to a persistent shock in inflation rate has a short-run effect (0-step), followed by an upward trend.

In the case of the Gini response to a shock in public debt, we can believe that public debt increases augments the level of income inequality in the long-run. This result, once again, follows the rationale as before, where a greater proportion of taxes will hamper low-income households disposable income if government public debt increases persist through time. On the contrary,

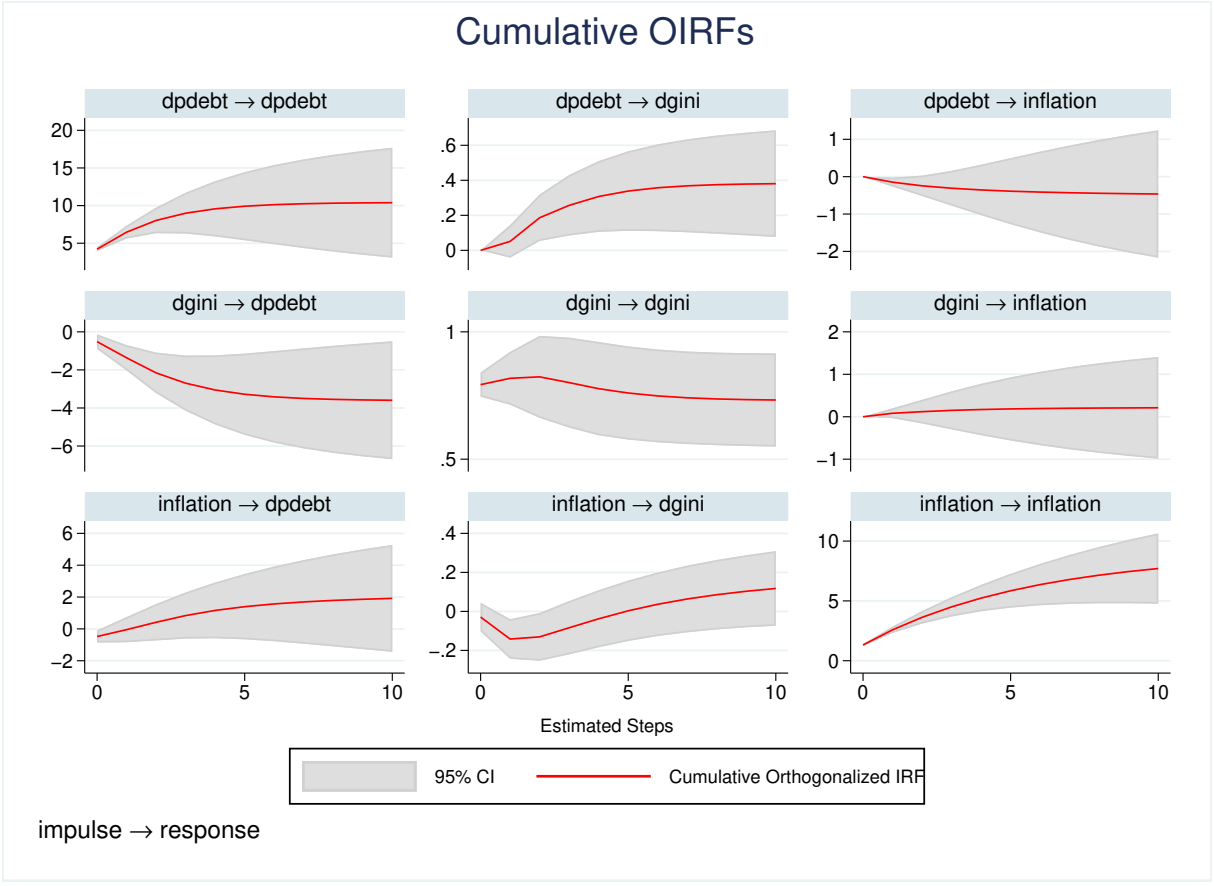


**Figure 5.4.** Cumulative OIRF

top income earners will benefit from higher disposable incomes, thus, less proportion of tax payments, and increases in interest payments from governments.

The panels that display the effects and responses on the same variables illustrate that if a shock is persistent on either one, the effect is positive and persistent. These results, merely, represent that the underlying economic structure is well-captured, given that a persistent shock in a variable, through time, will lead to a persistent increase in the variation of itself.

### 5.3. Forecast Error Variance Decomposition

The forecast error variance decomposition (FEVD) quantifies the magnitude of the shocks on the independent variables that explains the variation of the response variable. Table 5.2 presents the FEVD results, demonstrating the contribution of each variable to the variation of the response variable.

Hence, as shown in the first panel related to the contribution of each variable in the variation of Gini, we see that the changes in Gini coefficient has the largest percentage of variation, accounting for 92.35% in the 10-year forecast horizon, while public debt showcases a contribution of 4.38% and, inflation rate presents a contribution of 3.26%. The interesting result is that public debt variation increases from 0 to 4.38% in the 10-year forecast horizon, while inflation increases from 0.13 in the 1-year forecast horizon to 3.26% in the last year. In conclusion, we can say that

in the short-run the effects of exogenous shocks to the variations of public debt and inflation are minimal, but, in the long-run, they can contribute to the enhancement (or reduction) of inequality.

The second panel demonstrates the contribution of each variable to inflation rate forecast error. In this case, inflation rate accounts for 99% of the variation, while changes in government debt and Gini contribute with 0.58% and 0.14%, respectively. The downward trend of their contributions demonstrates that the inflation rate, in the long-run, is more conditioned to, perhaps, monetary shocks. Therefore, the evolution of debt and inequality are not constituents of the evolution of inflation rate.

Finally, the third panel showcases the results regarding the contribution of each variable for the variation of public debt forecasted error. In this case, we have that changes in public debt accounts for the most variation in itself with a value of 89%, while inflation rate accounts with 3%, and, in the case of Gini coefficient, the contribution is 7%. Contrary to the results obtained for inflation rate, here, we see that the variables have an upward trend evolution. Emphasizing that in the long-run, they can contribute to public debt variations. These validate the results obtained in the Granger Causality Test.

| Steps | Impulse Variable | | |
|---|---|---|---|
| | inflation | dgini | dpdebt |
| Response Variable: *dgini* | | | |
| 1 | 0.13 | 99.86 | 0 |
| 2 | 2.10 | 97.49 | 0.41 |
| 3 | 2.06 | 94.79 | 3.14 |
| 4 | 2.36 | 93.78 | 3.85 |
| 5 | 2.66 | 93.14 | 4.20 |
| 6 | 2.89 | 92.78 | 4.33 |
| 7 | 3.05 | 92.58 | 4.37 |
| 8 | 3.15 | 92.46 | 4.38 |
| 9 | 3.22 | 92.39 | 4.38 |
| 10 | 3.26 | 92.35 | 4.38 |
| Response Variable: *inflation* | | | |
| 1 | 1 | 0 | 0 |
| 2 | 99.16 | 0.20 | 0.64 |
| 3 | 99.12 | 0.18 | 0.70 |
| 4 | 99.15 | 0.17 | 0.67 |
| 5 | 99.19 | 0.16 | 0.65 |
| 6 | 99.22 | 0.15 | 0.63 |
| 7 | 99.24 | 0.15 | 0.608 |
| 8 | 99.25 | 0.15 | 0.596 |
| 9 | 99.27 | 0.15 | 0.60 |
| 10 | 99.27 | 0.14 | 0.581 |
| Response Variable: *dpdebt* | | | |
| 1 | 1.26 | 1.45 | 97.29 |
| 2 | 1.71 | 4.07 | 94.22 |
| 3 | 2.29 | 5.87 | 91.84 |
| 4 | 2.79 | 6.60 | 90.61 |
| 5 | 3.09 | 6.90 | 90.01 |
| 6 | 3.26 | 7.02 | 89.73 |
| 7 | 3.35 | 7.06 | 89.59 |
| 8 | 3.39 | 7.08 | 89.53 |
| 9 | 3.42 | 7.08 | 89.50 |
| 10 | 3.44 | 7.08 | 89.48 |

**Table 5.2.** Forecast Error Decomposition Variance of the PVAR model (%)

CHAPTER 6

# Robustness Tests

## 6.1. Impulse Response using Alternative Measures

In order to validate the results shown in the section above, we provide robustness checks. Here, we will use alternative measures of income inequality, namely the Income share of the Top 10%, applying the same model identification strategies as before.

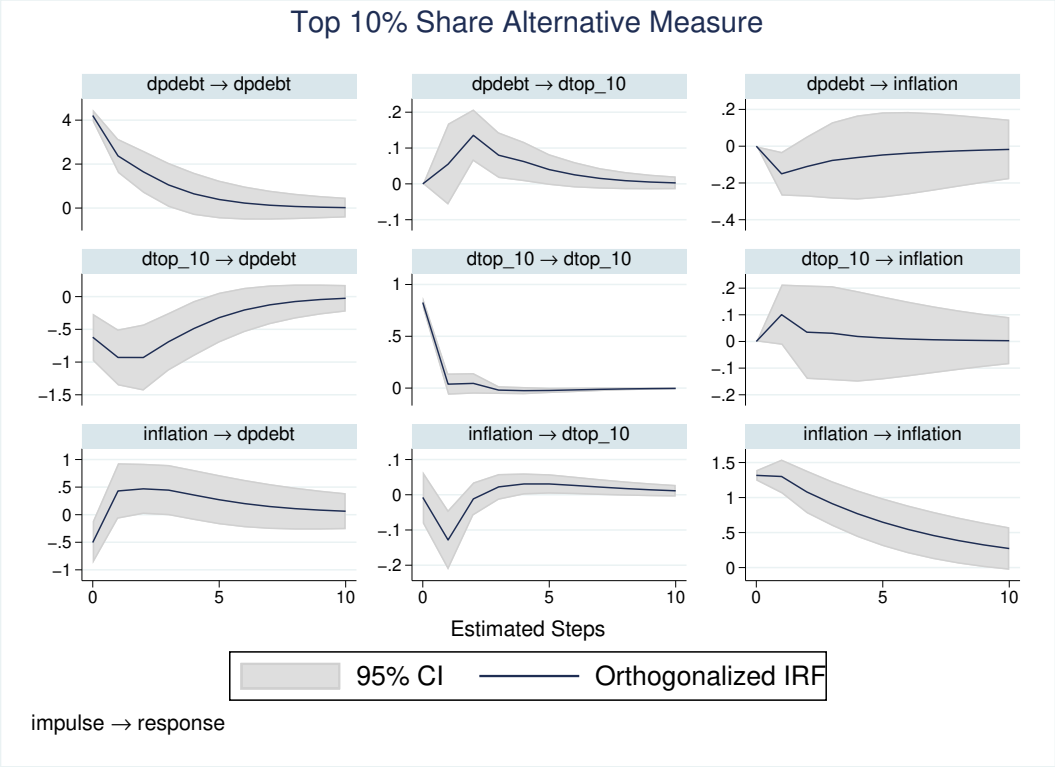


**Figure 6.1.** OIRFs of Top 10% Income Share as alternative measure

Hence, we can see that the graphical representation of the impulse response functions obtained using alternative measures, such as Top 10% Income share, imply the similar response functions.

The differences appear in the response function of the variation of the income share of the Top 10% to an increase in the first-differencing of government debt, where in the short-run is not significant, but in the 3rd year, it appears that an increase in government debt contributes to the income share of the top 10% earners. validating the arguments presented before. Once again, showcasing the detrimental effect of future taxes increases for the base of the income class and the interest-bearing argument in favor of the top income class. In addition to this, we see that an

increase of the change of top 10% income share leads to a decrease in public debt, this emphasizes the argument of the saddle-path of public debt, as the top 10% income earners increase their share of the income, the accumulation of debt decreases, providing a clearer validation for the argument of the crowding-in effect of private capital that compensates the reduction of the level of capital in steady-state.

In conclusion, we can confirm that the results obtained in the original model are data-driven and enhance the theoretical arguments that envisions the explanation of the different response functions.

### 6.2. Ordering of PVAR

After introducing alternative measures that capture the same dynamics, one should recall the possible Cholesky Decomposition bias due to the ordering of the dependent variables in our PVAR model.

In Figure 6.2, we can see that our results are robust to a different ordering of the variables in the model. The impulse response functions are similar to the ones obtained in the results section, the only slight change that occurs is the difference in the magnitude of the response. The same is shown on the Figure 6.3, where we treat inflation rate as the most endogenous variable. Here, one can see that, if inflation rate increases, the response of public debt will be positive and statistical significant, until the 3rd year. The remaining robustness checks are similar to our results, evidencing the robustness of our findings.

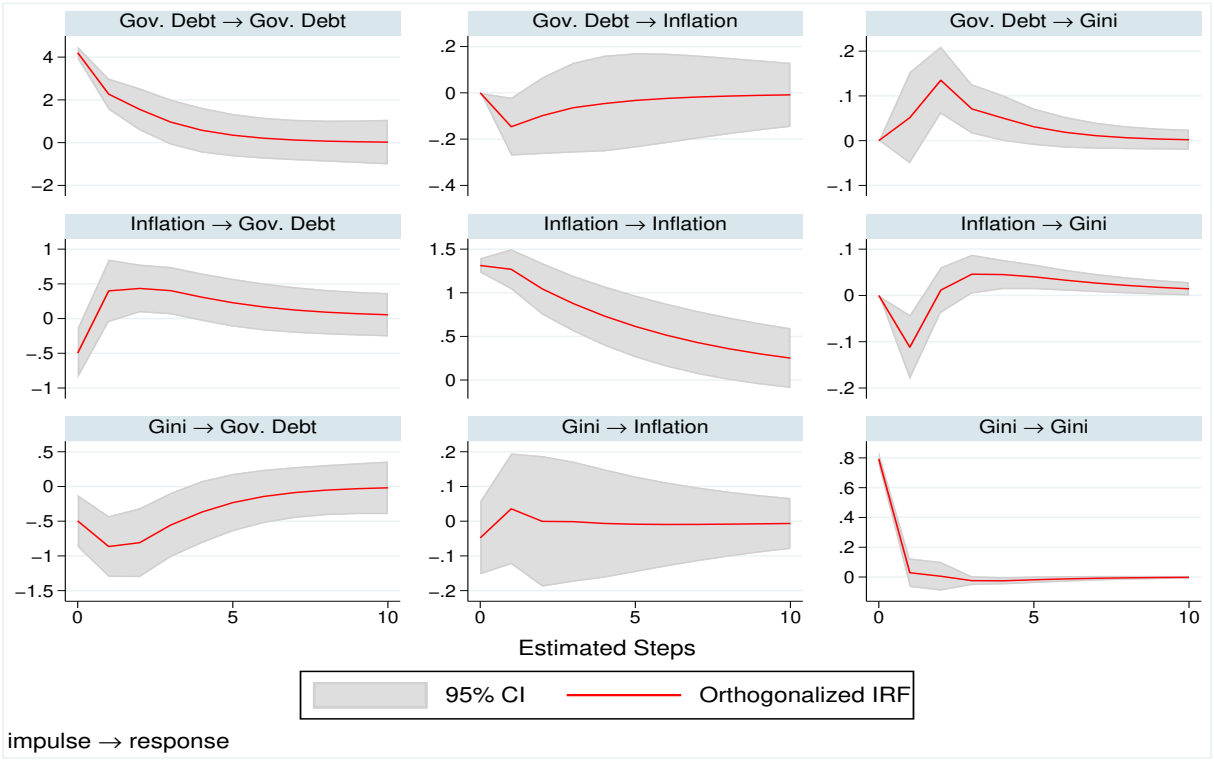


**Figure 6.2.** Ordering of PVAR: Gini, Inflation, public debt

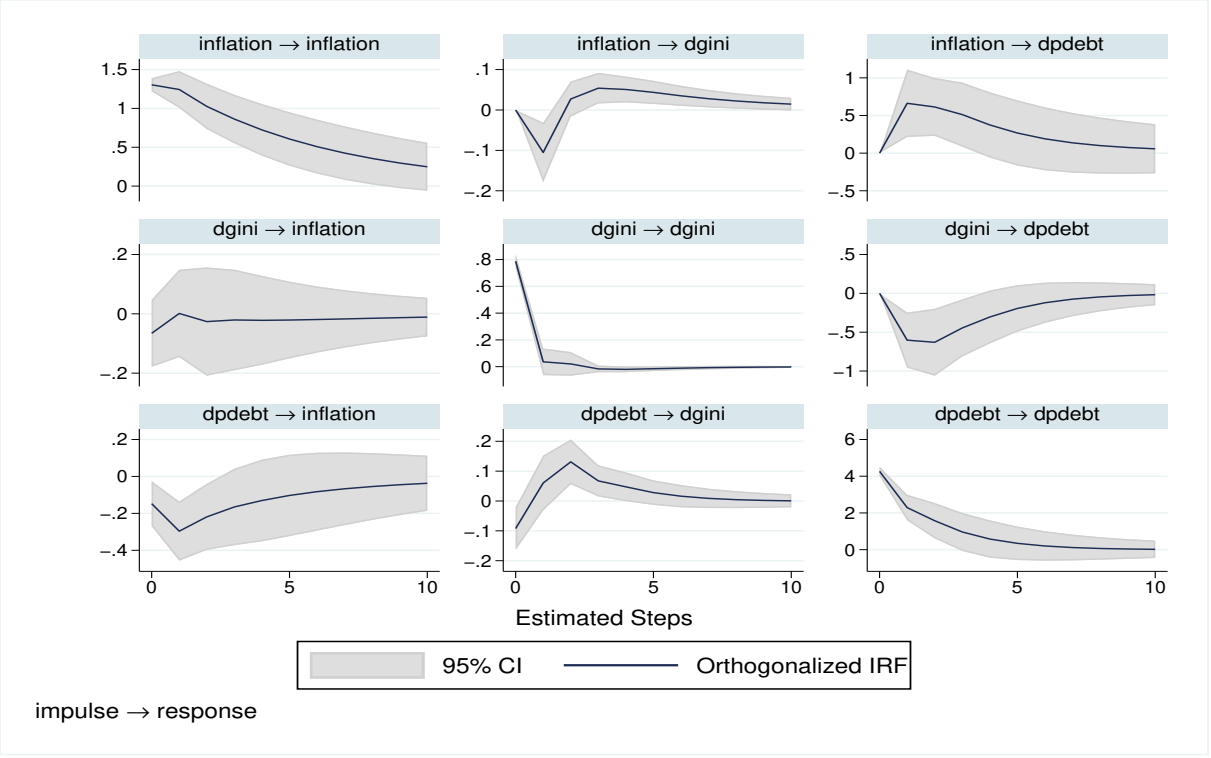


**Figure 6.3.** Ordering of PVAR: public debt, Gini, Inflation

### 6.3. GVAR Model: Heterogeneous Response

In order to account for different responses, thus emphasizing the impact of country-fixed effect, we will present the results of the GVAR model, which as Dees *et al.* (2007) stated are more suitable for inferring individual responses in a globalized econometric approach. See Appendix C for a clearer representation of this model.

The Global Vector Autoregressive Model, GVAR model, envisions a heterogeneous approach regarding the study of dynamic interdependencies. It differs from the previous PVAR approach, given that the model compels the estimation of individual VAR models for every country, which are then stacked together using a trade weight matrix that measures trade relationships between countries. The approach follows the work of Dees *et al.* (2007). In our case, the estimation of the GVAR constitutes an alternative specification to the main model, in which the intention is to provide information regarding the interactions of the variables for each country.

Hence, this subsection, intents to provide, the results regarding the modeling of important individual characteristics, where the results differ from our main model. Here, one can find the generalized IRFs (GIRFs) of responses to a one standard deviation shock to an identified variable. The results displayed are the ones where we can confirm a statistically significant result for 95% confidence interval bands. Regarding the countries that present non-significant responses, we "assume" that the homogeneous model can prompt an understanding for these dynamic interdependencies.

In Figure 6.4, we have the response functions of the first-differencing of public debt to a one standard deviation shock associated to Gini. The results found a positive statistically significant response for Portugal. Where an increase in inequality leads to a positive response in public debt for the following periods, thus, one should suspect that this relationship is conditioned by the process of diminished fiscal performance due to a level of higher inequality within the country (Larch, 2012). In the case of France, we see an opposing response from public debt to a shock in Gini coefficient (Figure A.1), where we see that income inequality and, perhaps social contribution, has played a key role in debt expansion.

The responses of inflation rate (Figure 6.5) are more divided between countries. Portugal showcases a negative short-lived response, until 8th period, to a shock in inflation rate. In the case of Spain and Italy, we see a more persistent effect.

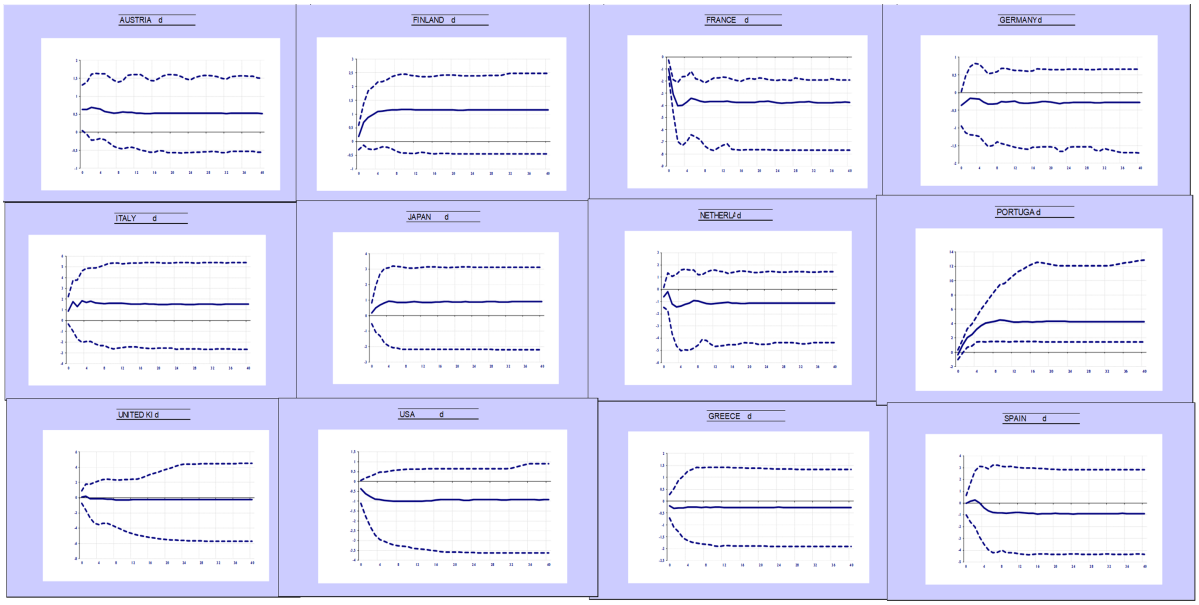


**Figure 6.4.** GIRFs of the reaction of Gov. Debt to a shock in Gini coefficient

When it comes to the response of Gini coefficient to a one s.e shock on public debt (Figure 6.6), it can be seen that a rise in public debt leads to a negative response of the first-differencing of income inequality, namely in the case of Germany and France, which occurs at the moment when the shock was introduced.

Germany's response can be seen through the fact that the German economy holds less public debt (in % of GDP), although presenting, in recent years, a rise in inequality. Thus, a rise in public debt can contribute to alleviate taxes for lower-income households and reduce inequality levels. In the case of France, we can see the same rationale as the one presented in the results' subsection, which follows the argument of the tax-smoothing argument of debt accumulation.

A shock on inflation rate demonstrates a negative response of the Gini coefficient for Finland, Germany, Italy, and Spain. These countries had seen their levels of inequality increase

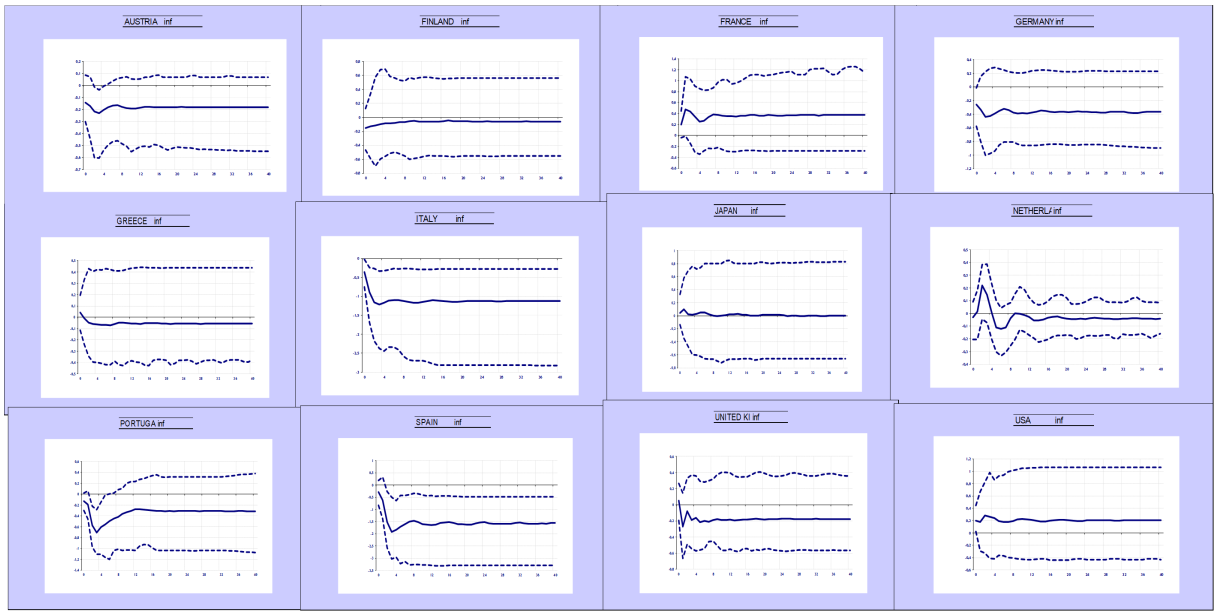


**Figure 6.5.** GIRFs of the reaction of Inflation Rate to a shock in Gini coefficient

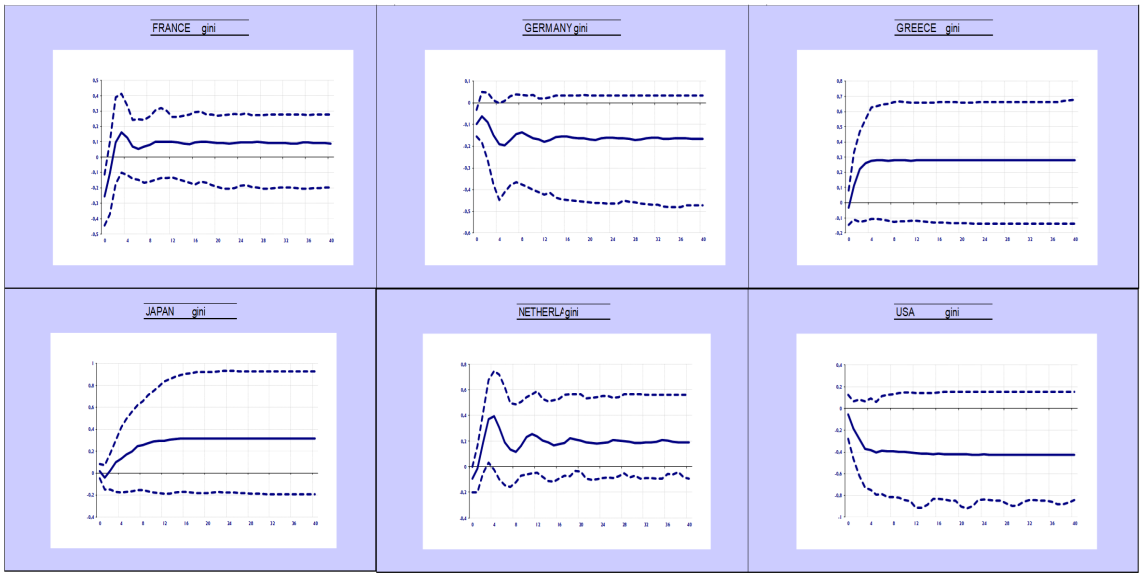


**Figure 6.6.** GIRFs of the reaction of Gini to a shock in public debt

substantially in the recent decades. The technological innovations, the increase in capital gains in opposition to labor income, have, perhaps, prompted an increase in income inequality. Recalling Binder (2019)'s argument related to the shift in correlation can prompt an understanding for these results and how this country may benefit from a stable increase in inflation levels. An important factor that enhances this argument is that the levels of trade balance within these economies are positive or close to zero, which induces that an inflationary process would favor an increase of wages, mainly for less productive sectors. If an economy faces higher inflation and is more dependent on outside products, this will lead to an increase in unemployment rate, as production and consumption from external countries would be preferred. But this is not the case

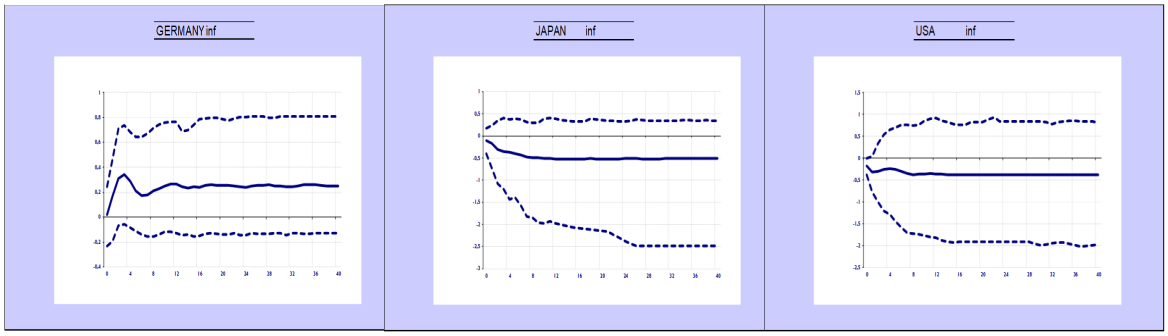


**Figure 6.7.** GIRFs of the reaction of Inflation to a shock in public debt

for these economies, where trade balance has showcased a consistent positive path, reflecting the resilience to the fluctuations of international trade.

When it comes to public debt responses to a shock in inflation rate (Figure 6.9), we see a negative response of the first-differencing of public debt, mainly in the case of Finland, France, and Greece. Thus, corroborating the results found before. We see that if inflation rate increases, then the reduction of public debt will persist in the case of Finland, and, it will be short-lived for France and Greece. In these countries, there has been a growing concern, regarding the levels of public debt, hence, we can believe the argument of the role of inflation rate in deleveraging the levels of public debt (Reinhart and Sbrancia, 2015).

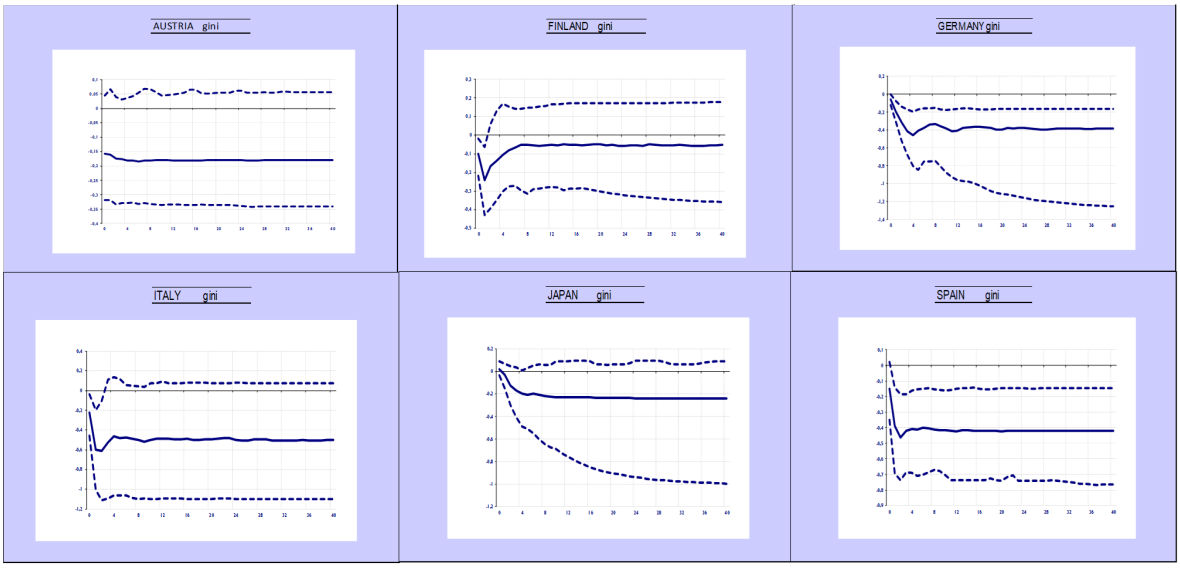


**Figure 6.8.** GIRFs of the reaction of Gini coefficient to a shock in Inflation Rate

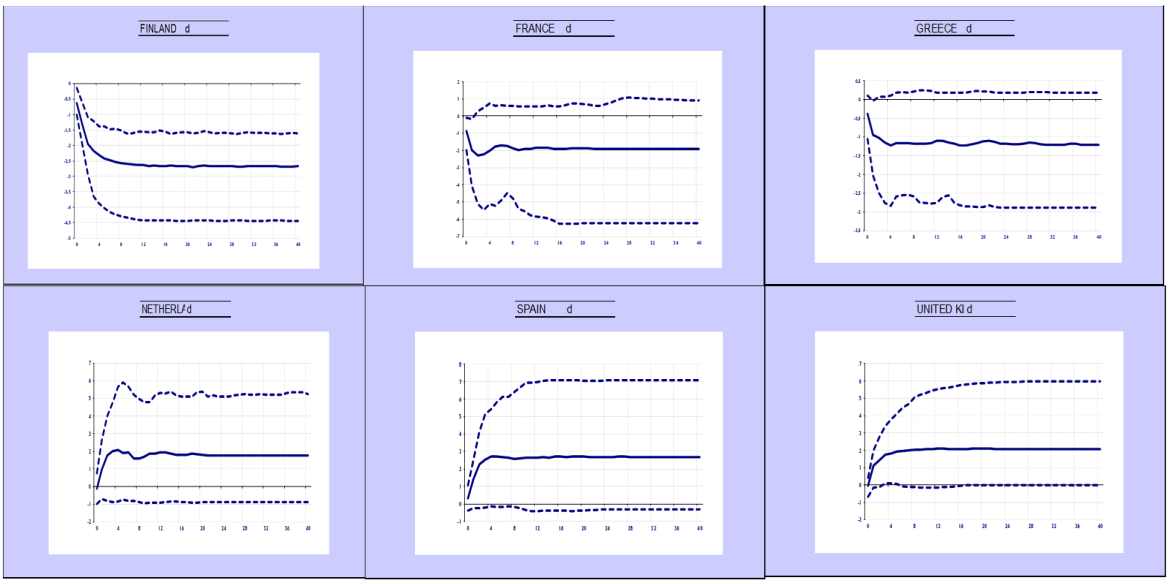


**Figure 6.9.** GIRFs of the reaction of Gov. Debt to a shock in Inflation Rate

CHAPTER 7

# Conclusion

This dissertation empirically analyzes the dynamic relationship between income inequality, public debt, and inflation rate on 14 developed countries, from 1980 to 2019. It presents a PVAR model to infer about the homogeneous responses from a cross-sectional data and illustrates the most significant results of a GVAR Model, which tests for heterogeneous responses among the countries.

The main empirical findings demonstrate that a shock to income inequality decreases public debt until the 5th period since the introduction of the shock, whereas inflation rate response is non-significant. The effect of public debt on income inequality is beneficial in the year of the shock, while displaying negative effects after the 2nd period until the 4th year. Inflation, on the other hand, perhaps due to its recent low levels, reacts negatively to an increase in public debt. Regarding inflation rate, we have found that there is a negative short-run effect, until the 2nd year, on the change in income inequality, followed by an increase in the medium-term. Moreover, public debt presents the expected behavior, whereas a shock in inflation rate results in a decrease of the variation of debt in the period of the introduction of the shock, followed by a rise that it is only significant until the 4th year.

The secondary findings, in respect to the heterogeneous model, conflict with some findings of the homogeneous model, thus, further contributing to this analysis. In a case of increase in income inequality, we would see that Portuguese public debt would increase, where the French case would result in the opposing effect. Additionally, the response of inflation rate to an increase in income inequality is negative for Spain, Portugal, and Italy, possibly, reflecting structural problems related to an increase in precautionary savings, lower levels of unemployment rate. In the case of an inflation rate shock, we see that is beneficial for income inequality changes in the case of Germany, Spain, Finland, and Italy. Additionally, the response of public debt to a shock in inflation validates the result of the homogeneous panel, where when looking at individual countries, we see that in the European Countries, which experienced an increased rise of public debt, the effect of public debt is negative to an inflation shock.

This work faced important shortcomings, that, hopefully, future researchers can mitigate. The reduced time-span of our dataset was not able to capture the effect of public debt in inflation rate. In the time-span of our study, inflation rate has been staggered in lower levels, while the environment of lower interest rates, allowed for governments to incur in public debt

accumulation. Thus, influencing the understanding of this interaction in moments of higher interest rates. In the same way, the time-period of this study is restrained by the data availability of Gini coefficient measures, harming the reflection on short-time effects between these variables, as well as, enlarging the number of observations, essential to a vector autoregressive approach.

Nevertheless, in order to foment future research in this topic, one should understand these dynamics, expanding the number of variables. Namely, the incorporation of consumption levels and savings rate, aiming at understanding the underlying behavior of the interaction between income inequality, public debt and inflation rate, attending to how different shocks condition the household's decisions. In addition to this, the GVAR model can contribute to the study of how income inequality propagates, namely, in the European region where there is a free movement of labor, capital, and products.

In conclusion, our results follow the literature, and constitutes a three-fold contribution to the economics literature. Firstly, the interpretation of a three-way relationship between public debt, Gini coefficient, and inflation rate. Secondly, it provides an overdue empirical approach to a theoretical discussion using a homogenous panel VAR, where individual structures are not considered, and providing a Global VAR model, that envisions an understanding of this dynamic relationship in a country-specific manner. Finally, this work sheds light on the importance of inequality in macroeconomic processes.

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APPENDIX A

# Graphical Representation of PVAR variables

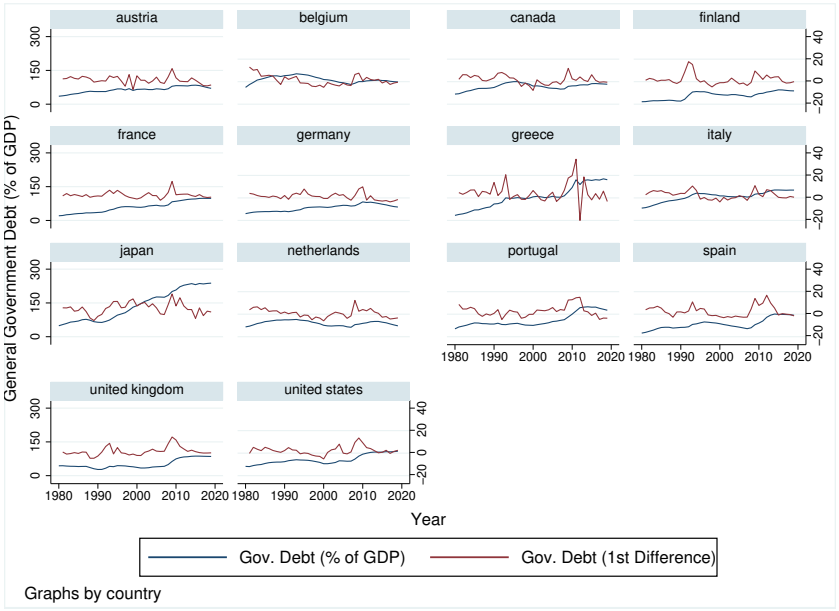


**Figure A.1.** Evolution of Public Debt (% of GDP) in levels and first-differences


**Figure A.2.** Evolution of Gini Coefficient Pre-Tax in levels and first-differences


**Figure A.3.** Evolution of Inflation Rate in levels and first-differences

APPENDIX B

# Summary Statistics by Group

| | Mean | S.d | Min | Max | Skewness | Kurtosis | count |
|---|---|---|---|---|---|---|---|
| **1980** | | | | | | | |
| gini | 42.93 | 4.53 | 35.42 | 49.73 | -0.19 | 2.08 | 14 |
| top_10 | 31.36 | 3.99 | 24.58 | 36.49 | -0.17 | 1.72 | 14 |
| inflation | 12.62 | 5.96 | 5.44 | 24.68 | 0.52 | 2.29 | 14 |
| pdebt | 37.36 | 16.84 | 10.89 | 74.65 | 0.39 | 2.96 | 14 |
| **1985** | | | | | | | |
| gini | 43.66 | 4.50 | 35.08 | 50.10 | -0.32 | 2.15 | 14 |
| top_10 | 31.79 | 4.02 | 24.28 | 37.14 | -0.41 | 2.06 | 14 |
| inflation | 6.84 | 5.76 | 2.04 | 19.46 | 1.47 | 3.86 | 14 |
| pdebt | 55.32 | 24.35 | 15.84 | 116.05 | 0.86 | 3.99 | 14 |
| **1990** | | | | | | | |
| gini | 44.77 | 4.60 | 37.08 | 51.98 | -0.16 | 2.35 | 14 |
| top_10 | 32.90 | 4.49 | 25.08 | 41.77 | 0.02 | 2.84 | 14 |
| inflation | 6.41 | 5.00 | 2.45 | 20.43 | 1.85 | 5.60 | 14 |
| pdebt | 60.16 | 28.84 | 13.86 | 126.66 | 0.61 | 3.29 | 14 |
| **1995** | | | | | | | |
| gini | 45.61 | 4.53 | 38.42 | 53.59 | -0.01 | 1.90 | 14 |
| top_10 | 33.62 | 3.71 | 27.53 | 39.96 | -0.03 | 2.01 | 14 |
| inflation | 2.90 | 2.27 | -0.09 | 8.93 | 1.35 | 4.64 | 14 |
| pdebt | 77.53 | 26.78 | 44.49 | 131.29 | 0.73 | 2.28 | 14 |
| **2000** | | | | | | | |
| gini | 47.21 | 4.98 | 38.19 | 55.68 | 0.19 | 2.22 | 14 |
| top_10 | 35.62 | 4.33 | 27.67 | 42.86 | 0.08 | 2.22 | 14 |
| inflation | 2.28 | 1.10 | -0.69 | 3.43 | -1.47 | 4.84 | 14 |
| pdebt | 72.64 | 30.68 | 36.79 | 137.89 | 0.83 | 2.44 | 14 |
| **2005** | | | | | | | |
| gini | 47.69 | 5.02 | 40.76 | 56.55 | 0.43 | 2.00 | 14 |
| top_10 | 36.16 | 4.78 | 29.72 | 45.65 | 0.55 | 2.34 | 14 |
| inflation | 2.09 | 1.05 | -0.29 | 3.55 | -0.63 | 3.17 | 14 |
| pdebt | 75.90 | 36.53 | 39.58 | 176.62 | 1.53 | 5.13 | 14 |
| **2010** | | | | | | | |
| gini | 47.15 | 4.67 | 40.63 | 57.27 | 0.83 | 2.80 | 14 |
| top_10 | 35.56 | 4.72 | 29.17 | 44.95 | 0.78 | 2.62 | 14 |
| inflation | 1.69 | 1.14 | -0.74 | 4.71 | 0.72 | 5.84 | 14 |
| pdebt | 95.84 | 40.90 | 46.90 | 207.68 | 1.53 | 5.11 | 14 |
| **2015** | | | | | | | |
| gini | 47.50 | 5.04 | 41.08 | 58.79 | 0.82 | 2.83 | 14 |
| top_10 | 36.00 | 5.04 | 29.26 | 45.68 | 0.74 | 2.52 | 14 |
| inflation | 0.22 | 0.72 | -1.74 | 1.13 | -1.44 | 5.06 | 14 |
| pdebt | 110.24 | 46.38 | 63.64 | 231.34 | 1.45 | 4.45 | 14 |
| **2019** | | | | | | | |
| gini | 47.15 | 4.88 | 41.28 | 58.25 | 1.06 | 3.06 | 14 |
| top_10 | 35.87 | 4.77 | 29.41 | 45.46 | 0.95 | 2.87 | 14 |
| inflation | 1.22 | 0.70 | 0.25 | 2.63 | 0.30 | 2.29 | 14 |
| pdebt | 105.98 | 51.07 | 48.38 | 237.95 | 1.37 | 4.36 | 14 |
| **Total** | | | | | | | |
| gini | 45.97 | 4.87 | 34.14 | 58.87 | 0.27 | 2.92 | 560 |
| top_10 | 34.30 | 4.62 | 23.28 | 46.02 | 0.34 | 3.13 | 560 |
| inflation | 3.68 | 4.40 | -1.74 | 28.38 | 2.59 | 10.48 | 560 |
| pdebt | 76.40 | 39.35 | 10.89 | 237.95 | 1.52 | 6.29 | 560 |
| *N* | 560 | | | | | | |

**Table B.1.** Descriptive Statistics by Year

| | Mean | S.d | Min | Max | Skewness | Kurtosis | count |
|---|---|---|---|---|---|---|---|
| **Austria** | | | | | | | |
| gini | 43.67 | 1.34 | 40.98 | 47.43 | 0.37 | 3.46 | 40 |
| top_10 | 33.83 | 1.07 | 31.89 | 37.48 | 1.23 | 5.10 | 40 |
| inflation | 2.52 | 1.47 | 0.51 | 6.80 | 1.28 | 4.37 | 40 |
| pdebt | 64.20 | 13.24 | 35.40 | 84.40 | -0.35 | 2.52 | 40 |
| **Belgium** | | | | | | | |
| gini | 44.34 | 0.82 | 42.84 | 46.11 | 0.02 | 2.04 | 40 |
| top_10 | 32.27 | 0.74 | 30.93 | 33.81 | 0.31 | 2.32 | 40 |
| inflation | 2.74 | 2.06 | -0.05 | 8.73 | 1.45 | 4.41 | 40 |
| pdebt | 109.58 | 14.65 | 74.65 | 135.04 | -0.02 | 2.32 | 40 |
| **Canada** | | | | | | | |
| gini | 50.83 | 2.14 | 46.31 | 53.70 | -0.41 | 1.91 | 40 |
| top_10 | 38.13 | 2.55 | 33.81 | 41.69 | -0.26 | 1.57 | 40 |
| inflation | 3.14 | 2.69 | 0.17 | 12.47 | 2.04 | 6.90 | 40 |
| pdebt | 78.48 | 14.03 | 44.91 | 100.24 | -0.57 | 2.78 | 40 |
| **Finland** | | | | | | | |
| gini | 41.36 | 2.63 | 35.92 | 44.66 | -0.47 | 1.85 | 40 |
| top_10 | 30.22 | 3.45 | 23.80 | 34.58 | -0.48 | 1.63 | 40 |
| inflation | 3.09 | 3.05 | -0.21 | 11.59 | 1.37 | 4.11 | 40 |
| pdebt | 38.81 | 17.45 | 10.89 | 63.64 | -0.32 | 1.70 | 40 |
| **France** | | | | | | | |
| gini | 43.75 | 0.95 | 41.52 | 45.26 | -0.46 | 2.09 | 40 |
| top_10 | 32.63 | 0.98 | 29.93 | 34.07 | -0.82 | 3.31 | 40 |
| inflation | 3.03 | 3.40 | 0.04 | 13.56 | 2.10 | 6.39 | 40 |
| pdebt | 59.80 | 24.98 | 20.83 | 98.32 | 0.13 | 1.80 | 40 |
| **Germany** | | | | | | | |
| gini | 44.48 | 3.53 | 39.41 | 49.93 | 0.17 | 1.58 | 40 |
| top_10 | 33.06 | 3.41 | 28.02 | 38.26 | 0.19 | 1.62 | 40 |
| inflation | 2.09 | 1.51 | -0.13 | 6.34 | 1.16 | 3.83 | 40 |
| pdebt | 56.21 | 14.88 | 30.25 | 82.38 | -0.01 | 1.84 | 40 |
| **Greece** | | | | | | | |
| gini | 48.45 | 2.50 | 44.49 | 54.25 | 0.60 | 2.73 | 40 |
| top_10 | 35.15 | 2.30 | 31.42 | 40.29 | 0.47 | 2.40 | 40 |
| inflation | 8.60 | 8.33 | -1.74 | 24.68 | 0.59 | 1.88 | 40 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| pdebt | 103.94 | 49.41 | 22.53 | 184.76 | 0.22 | 2.10 | 40 |
| **Italy** | | | | | | | |
| gini | 40.73 | 3.27 | 34.14 | 44.96 | -0.79 | 2.35 | 40 |
| top_10 | 28.97 | 2.86 | 23.28 | 32.89 | -0.70 | 2.26 | 40 |
| inflation | 4.70 | 4.99 | -0.09 | 21.06 | 1.85 | 5.78 | 40 |
| pdebt | 106.05 | 22.29 | 54.88 | 135.37 | -0.69 | 2.77 | 40 |
| **Japan** | | | | | | | |
| gini | 51.81 | 2.83 | 47.04 | 55.93 | -0.29 | 1.74 | 40 |
| top_10 | 41.49 | 3.54 | 35.93 | 46.02 | -0.26 | 1.51 | 40 |
| inflation | 0.99 | 1.73 | -1.33 | 7.77 | 1.82 | 7.39 | 40 |
| pdebt | 138.87 | 67.74 | 48.81 | 237.95 | 0.21 | 1.49 | 40 |
| **Netherlands** | | | | | | | |
| gini | 39.01 | 1.85 | 35.43 | 42.35 | -0.07 | 1.96 | 40 |
| top_10 | 28.05 | 1.29 | 26.08 | 31.02 | 0.18 | 1.92 | 40 |
| inflation | 2.26 | 1.53 | -0.69 | 6.74 | 1.18 | 5.03 | 40 |
| pdebt | 60.45 | 10.60 | 41.97 | 76.77 | -0.08 | 1.70 | 40 |
| **Portugal** | | | | | | | |
| gini | 47.84 | 2.57 | 41.02 | 51.44 | -0.86 | 3.01 | 40 |
| top_10 | 35.87 | 2.92 | 27.75 | 39.62 | -1.07 | 3.50 | 40 |
| inflation | 6.81 | 7.41 | -0.84 | 28.38 | 1.31 | 3.76 | 40 |
| pdebt | 74.38 | 30.45 | 35.00 | 132.94 | 0.99 | 2.39 | 40 |
| **Spain** | | | | | | | |
| gini | 46.35 | 0.91 | 45.17 | 48.90 | 1.02 | 3.26 | 40 |
| top_10 | 34.98 | 0.85 | 33.69 | 37.45 | 1.03 | 3.74 | 40 |
| inflation | 4.67 | 4.09 | -0.50 | 15.56 | 1.25 | 3.89 | 40 |
| pdebt | 56.33 | 23.71 | 16.13 | 100.70 | 0.62 | 2.44 | 40 |
| **United Kingdom** | | | | | | | |
| gini | 46.64 | 2.63 | 41.48 | 50.61 | -0.57 | 2.30 | 40 |
| top_10 | 34.45 | 3.01 | 29.03 | 38.66 | -0.47 | 1.95 | 40 |
| inflation | 3.70 | 3.31 | 0.37 | 17.97 | 2.55 | 10.45 | 40 |
| pdebt | 50.96 | 20.20 | 27.54 | 86.92 | 0.94 | 2.21 | 40 |
| **United States** | | | | | | | |
| gini | 54.39 | 3.45 | 47.00 | 58.87 | -0.49 | 2.20 | 40 |
| top_10 | 41.17 | 3.53 | 34.20 | 45.68 | -0.40 | 2.00 | 40 |
| inflation | 3.22 | 2.42 | -0.36 | 13.55 | 2.55 | 11.08 | 40 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| pdebt | 71.52 | 20.96 | 40.39 | 108.68 | 0.63 | 2.10 | 40 |
| **Total** | | | | | | | |
| gini | 45.97 | 4.87 | 34.14 | 58.87 | 0.27 | 2.92 | 560.00 |
| top_10 | 34.30 | 4.62 | 23.28 | 46.02 | 0.34 | 3.13 | 560.00 |
| inflation | 3.68 | 4.40 | -1.74 | 28.38 | 2.59 | 10.48 | 560.00 |
| pdebt | 76.40 | 39.35 | 10.89 | 237.95 | 1.52 | 6.29 | 560.00 |
| *N* | 560 | | | | | | |

**Table B.2.** Descriptive Statistics by Country

APPENDIX C

# GVAR Model

In this section, the intention is to provide a description of the Global Vector Autoregression Model (GVAR) used to assess the relationship between income inequality, public debt and inflation rate in global economy, increasingly complex, where global interactions constitute a key determinant in understanding macroeconomic shocks.

## C.1. THE GVAR Approach

In this appendix, we provide a description of the Global Vector Autoregression Model (GVAR) usually used to assess spatial propagation of shocks. This serves the purpose of providing a broader information in robustness checks section, representing a heterogeneous model to identify dynamic interdependencies at the individual country-model. Thus, this section is subdivided into an explanation of the theoretical background of the GVAR model, followed by a brief description of the data and specification tests. Note, that, due to the number of results obtained in this process, we only showcase the most elementary ones and the Generalized Impulse Response Functions that presented statistically significant results.

Therefore, the GVAR Model follows a two-step procedure: i) the estimation of single-country VARX (VECM) which cross-country relations are explicitly model; ii) a global VAR model that groups the country-specific VARs, accounting for common factors. Thus, the model is able to capture individual shocks on public debt and income inequality that have a greater impact for a given economy, but it provides a clearer framework for understanding the international behavior concerning the dynamics of the mentioned variables. Based on the work developed by Dees *et al.* (2007), each individual country $i \in \{0, \ldots, N\}$ is modelled as a VARX $(q_i, q_i^*, l_i)$.

$$x_{i,t} = \alpha_{i,0} + \alpha_{i,1}t + \sum_{j=1}^{q_i} \alpha_{i,j} x_{i,t-j} + \sum_{j=0}^{q_i^*} \beta_{i,j} x_{i,t-j}^* + \sum_{j=0}^{l_i} \gamma_{i,j} d_{t-j} + u_{i,t} \tag{1}$$

In Eq. (1) we have $\alpha_{i,0}$ as a constant, $t$ is a linear trend, $\alpha_{i,j}$, $\beta_{i,j}$, and $\gamma_{i,j}$ are matrices of coefficients, and $u_{i,t}$ is a vector of country-specific shocks which are assumed to be uncorrelated with a full variance-covariance matrix. The $k_i \times 1$ vector $x_{i,t}$ contains the set of domestic

(endogenous) variables, which are augmented by the $k_i^* \times 1$ vector $x_{i,t-j}^*$ of foreign (weakly exogenous) variables, which represent the influence of the economic partners with a given country, and $d_t$ which is a set of strictly exogenous variable variables, which accounts for global shocks for every country model. In our case, we do not introduce any global variable. The set of foreign variables is constructed by the usage of weighted average trade relationships between the domestic economy and other countries.

$$x_{i,t}^* := \sum_{j \neq i} w_{i,j} x_{j,t} \tag{1.1}$$

The $w_{i,j}$ determines the strength of the economic relationships between countries, based on bilateral trade relationships. it's this set of weights that allows GVAR modelling to be a close representation of the world economy, since it allows for some geographical propagation of a shock. Regarding the set of weights, there is a great length of papers that has emphasized the trade share as the most representational proxy for economic ties. One should note, that in Eq (1) the domestic variables, present on the right side of the equation, relates to the domestic variables entered in lagged form, predetermined by the AIC. It's possible to write Eq. (1) in a more compactly form, defining the $z_{i,t} = (x_{i,t}^{'}, x_{i,t}^{*'})^{'}$ that contains both the endogenous variables and foreign variables, which can be efficiently written if we assume $p_i = max(q_i, q_i^*)$ and neglect the strictly exogenous variables. Then, Eq.(1), becomes:

$$A_{i,0} z_{i,t} = \alpha_{i,0} + \alpha_{i,1} t + \sum_{j=1}^{p_i} A_{i,j} z_{i,t-j} + u_{i,t} \tag{2}$$

The single country-models are linked via a connectivity matrix which can be represented as $W_i$ , and ensures that the all the domestic variables are linked. It is the same procedure as before, but now related to the model. Hence, the coefficient matrix can be represented as:

$$W_i = \begin{pmatrix} 0 & \dots & I_{k_i} & \dots & 0 \\ w_{i,0} I_{k_i^*} & \dots & w_{i,j} I_{k_i^*} & \dots & w_{i,N} I_{k_i^*} \end{pmatrix} \tag{1.2}$$

Thus, $W_i$ is a $(k_i + k_i^*) \times K$ which transforms the matrices of the coefficients of estimated coefficients, linking all countries.

$$A_{i,0} W_i x_t = \sum_{j=1}^{p_i} A_{i,j} W_i x_{i,t-j} + u_{i,t} \tag{3}$$

Finally, after invoking the connectivity matrix to link the coefficient matrices, we can stack the models.

$$G_0 x_t = \alpha_{i,0} + \alpha_{i,1} t + \sum_{j=1}^{p} G_j x_{i,t-j} + u_{i,t} \tag{4}$$

Where $p = max(p_0, \ldots, p_N)$, $a_0$ refers to the stacked coefficients on the constant, $a_1$ to the stacked coefficients on the time trend. The remaining parameters are related to the interconnectedness of the coefficient matrices of the domestic and foreign variables.

$$G_0 = \begin{bmatrix} A_{0,0}W^0 \\ A_{1,0}W^1 \\ \vdots \\ A_{N,0}W^0 \end{bmatrix}, G_j = \begin{bmatrix} A_{0,j}W^0 \\ A_{1,j}W^1 \\ \vdots \\ A_{N,j}W^0 \end{bmatrix}, u_t = \begin{bmatrix} u_{0,t} \\ u_{1,t} \\ \vdots \\ u_{N,t} \end{bmatrix} \tag{4.1}$$

Hence, the global VAR of order $(p)$ can be represented in the following manner:

$$x_t = b_0 + b_1 t + \sum_{j=1}^{p} F_j x_{t-j} + e_t \tag{5}$$

The Eq. (5) represents an empirical representation of the world economy with the economies linked by the introduction of the bilateral trade share between the economies, where $F_j = G_0^{-1} G_j$, $b_0 = G_0^{-1} a_0$, $b_1 = G_0^{-1} a_1$, $e_t = G_0^{-1} u_t$. Thus, the model allows for a mimic of spatial propagation due to the interconnectedness between economies by the introduction of bilateral trade shares, representing a fundamental part of the global VAR modelling. Considering the relationships between economies, this essential step reduces the so-called curse of dimensionality, and envisions a reduce error correlation between economies given that a great percentage of the error is explained by the linkage between single country VARs, as well as the dependence of domestic variables on global variables. Permitting an estimation of a model that expands the empirical power of macroeconomic empirical approaches.

### C.1.1. Generalized Impulse Response Functions

A recurring approach for identifying shocks in VARs, is the orthogonalization of Impulse Response Functions, developed by Sims (1980). This requires the setting of P, as a Cholesky decomposition factor, which is conditioned by the ordering of the variables. In a global setting,

the introduction of cross-country interactions and high dimensionality, further augments the complication of identifying the ordering of the variables and, thus, the uniqueness of P. Thus, the literature has fallen on Generalized Impulse Response Function (GIRFs) approach, to ensure that the identification of shocks is not dependent on some canonical system or economic theory (Dees *et al.*, 2007; Pesaran *et al.*, 2004). See Chudik and Pesaran (2016), for a complete description.

Therefore, GIRFs have two fundamental differences, compared to the OIRF. Firstly, they are not dependent on the ordering of the variables, thus there isn't any orthogonalization of the residuals, the variance-covariance matrix is calculated using historical correlations between the residuals. Secondly, the GIRFs are used to identify the mechanism of the propagation of shocks, not aiming at understanding causal relationships. However, we overcome this problem by estimating individual shocks for the mentioned variables, individually. Observing the shock within the country, disregarding the spatial shocks. Hence, this could constitute a place for future research.

Thus, the empirical representation of the GIRFs is:

$$GIRF(y_t, e_t, n) = \frac{A_n G^{-1} \sum_e s_j}{\sqrt{s_j^{'} \sum_e s_j}} \tag{C.1}$$

Thus, $s_j$ is a shock vector that contains the shocks of $j$th element. $A_n$ is the matrix that contains the vector moving average representation.

In the section of the robustness checks, we use the GIRFs as a representation of the dynamic interactions among the variables, due to the data-driven approach. The historical correlation used in this Impulse Response function, allow us to understand these dynamics through data, unconstrained by theoretical assumptions, thus, emphasizing the response functions for hypothetical future scenarios, based on past registered values. In this case, we identify the shocks within the country, excluding the spatial propagation of shocks, thus, overcoming the second characteristic of the GIRFs.

## C.2. Data and Model Identification Tests

### Data

The data used in this model compels the same presented in the section Data, where we have a yearly time-series that reaches from 1980 to 2019. The list of countries is reduced, we exclude Canada, Belgium, because the estimation process of the GVAR model doesn't allow the inclusion of missing observations. The variables included are equal to the ones explained in the section above, where the alternative measures are not introduced as instruments.

The weight trade matrix is compelled by the average of the sum of imports and exports weighted by the total sum of trade flows of the country at hand, between the years 2014-2018, created using the Direction of Trade Statistics Database retrieved from the International Monetary Fund. In respect to the advantage of the GVAR model in differencing economies given the estimation of individual VARs, this model, also, captures the dimension of the economies. In our case, this is reflected by the average of the value of Gross Domestic Product at constant 2017 international $, between the years of 2016 and 2019.

Hence, our countries are treated differently as compared to the PVAR model, in this case, we differ from treating every economy as a small-open economy but include closed economies when it's the case. So, Japan, UK, and USA are treated as close economy, while the remaining countries are small-open economies. This is done, by defining inflation rate as a foreign variable for every country, while public debt enters as foreign variable in small-open economies. Gini coefficient is set to be only endogenous, due to being a measure dependent on the structure of social and economic dimensions, while it can have same spatial propagation, this occurs, more, by the propagation of economic theory or policy decisions, than to the propagation of income inequalities.

**Specification Tests**

Here, we present a description of the results regarding the specification tests, the scope of this work is not inferring a complete description of the results found but give a clear idea about the results found in GVAR: Heterogeneous Responses.

Thus, in Table B.1, it can be seen the trade weight matrix, the information presented in this table, constitute the relationship between economies, which are consistent to the real trade situation between countries. As a robust result, we present the total sum of the columns, where the requirement is to be 1. As it is the case.

Table B.2, Table B.3, Table B.4, showcase the summary statistics of the endogenous variables, already presented, for each country that enters the model. Table B.5 presents the panel unit root test, conducted by Augmented Dickey Fuller Test for the variables in levels, with and without trend. The results between countries and variables are different, achieving only stationarity in inflation rate, except for Italy and Spain. Thus, we estimate the GVAR model introducing these variables in first differences. Table B.6 relates to the lag-selection criteria which is conducted by AIC (Akaike Criteria Information) and we present the results of the Cointegration relationships between the variables within the model. The complete description of the cointegration relationships is far behind the scope of this work, which can be conducted in further research.

Finally, the table B.7 presents the test for weak exogeneity of foreign variables, where the assumption is to test if the model is misspecified. We are testing if the foreign variable is weakly exogenous and, thus can enter the model as a foreign variable, or its importance relates to a behavior of an endogenous variable. In this case, we can reject the null hypotheses of strong exogeneity for all foreign variables, except for inflation rate in Portugal. However, we will assume that given the structure of the Portuguese economy follows a small-open economy within the European Monetary Union, the inflation rate of the other European economies can propagate to Portugal. The missing observations relate to the findings of no cointegration relationships, Table B.6, as well as to the prior assumption of not including public debt as foreign variables for closed economies and defining gini as endogenous variables.

| Country | AUS | FIN | FRA | DEU | GRE | ITA | JAP | NLD | POR | ESP | GBR | USA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AUS | | 0.02 | 0.02 | 0.10 | 0.02 | 0.05 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 |
| FIN | 0.01 | | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| FRA | 0.06 | 0.07 | | 0.17 | 0.10 | 0.20 | 0.05 | 0.13 | 0.14 | 0.24 | 0.13 | 0.11 |
| DEU | 0.62 | 0.37 | 0.32 | | 0.25 | 0.29 | 0.13 | 0.41 | 0.18 | 0.23 | 0.27 | 0.23 |
| GRE | 0.00 | 0.01 | 0.01 | 0.01 | | 0.02 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | |
| ITA | 0.11 | 0.06 | 0.14 | 0.11 | 0.25 | | 0.04 | 0.07 | 0.07 | 0.13 | 0.07 | 0.09 |
| JAP | 0.01 | 0.03 | 0.02 | 0.03 | 0.01 | 0.02 | | 0.03 | 0.01 | 0.02 | 0.04 | 0.27 |
| NLD | 0.05 | 0.18 | 0.11 | 0.21 | 0.11 | 0.08 | 0.05 | | 0.07 | 0.08 | 0.16 | 0.08 |
| POR | 0.00 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | | 0.10 | 0.01 | 0.01 |
| ESP | 0.03 | 0.04 | 0.13 | 0.07 | 0.09 | 0.10 | 0.02 | 0.05 | 0.42 | | 0.07 | 0.03 |
| GBR | 0.04 | 0.09 | 0.10 | 0.12 | 0.08 | 0.09 | 0.06 | 0.15 | 0.06 | 0.10 | | 0.15 |
| USA | 0.07 | 0.11 | 0.12 | 0.15 | 0.06 | 0.13 | 0.63 | 0.11 | 0.04 | 0.07 | 0.23 | |
| Total | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

**Table C.1.** Trade Weight Matrix

| Gov. Debt | Mean | Median | Max. | Min. | Std. | Skew | Kurt. | J-Bera | Prob. |
|---|---|---|---|---|---|---|---|---|---|
| AUS | 64,2 | 65,32 | 84,4 | 35,4 | 13,24 | -0,34 | 2,39 | 1,23 | 0,541 |
| FIN | 109,58 | 106,24 | 135,04 | 74,65 | 14,65 | -0,02 | 2,21 | 0,77 | 0,679 |
| FRA | 38,81 | 41,98 | 63,64 | 10,89 | 17,45 | -0,3 | 1,61 | 3,49 | 0,175 |
| DEU | 59,8 | 60,38 | 98,32 | 20,83 | 24,98 | 0,12 | 1,71 | 2,5 | 0,287 |
| GRE | 56,21 | 59,3 | 82,38 | 30,25 | 14,88 | -0,01 | 1,75 | 2,25 | 0,325 |
| ITA | 103,94 | 101,4 | 184,76 | 22,53 | 49,41 | 0,22 | 2 | 1,67 | 0,434 |
| JAP | 106,05 | 107,81 | 135,37 | 54,88 | 22,29 | -0,67 | 2,64 | 3,27 | 0,195 |
| NLD | 138,87 | 134,51 | 237,95 | 48,81 | 67,74 | 0,2 | 1,42 | 4,07 | 0,131 |
| POR | 60,45 | 61,75 | 76,77 | 41,97 | 10,6 | -0,08 | 1,62 | 2,85 | 0,241 |
| ESP | 74,38 | 59,1 | 132,94 | 35 | 30,45 | 0,95 | 2,27 | 7,19 | 0,027 |
| GBR | 56,33 | 52,26 | 100,7 | 16,13 | 23,71 | 0,6 | 2,32 | 3,07 | 0,215 |
| USA | 50,96 | 41,54 | 86,92 | 27,54 | 20,2 | 0,9 | 2,1 | 6,89 | 0,032 |

**Table C.2.** Individual Countries Summary Statistics: Gov. Debt

| Inflation | Mean | Median | Max. | Min. | Std. | Skew | Kurt. | J-Bera | Prob. |
|---|---|---|---|---|---|---|---|---|---|
| AUS | 2,52 | 2,12 | 6,8 | 0,51 | 1,47 | 1,23 | 4,15 | 14,07 | 0,001 |
| FIN | 2,74 | 2,11 | 8,73 | -0,05 | 2,06 | 1,4 | 4,19 | 17,33 | 0 |
| FRA | 3,09 | 1,88 | 11,59 | -0,21 | 3,05 | 1,32 | 3,9 | 14,6 | 0,001 |
| DEU | 3,03 | 1,94 | 13,56 | 0,04 | 3,4 | 2,02 | 6,08 | 48,49 | 0 |
| GRE | 2,09 | 1,69 | 6,34 | -0,13 | 1,51 | 1,12 | 3,64 | 10,17 | 0,006 |
| ITA | 8,6 | 4,43 | 24,68 | -1,74 | 8,33 | 0,57 | 1,79 | 4,43 | 0,109 |
| JAP | 4,7 | 2,78 | 21,06 | -0,09 | 4,99 | 1,79 | 5,5 | 35,84 | 0 |
| NLD | 0,99 | 0,55 | 7,77 | -1,33 | 1,73 | 1,75 | 7,02 | 54,03 | 0 |
| POR | 2,26 | 2,14 | 6,74 | -0,69 | 1,53 | 1,14 | 4,78 | 16,15 | 0 |
| ESP | 6,81 | 3,16 | 28,38 | -0,84 | 7,41 | 1,26 | 3,57 | 12,38 | 0,002 |
| GBR | 4,67 | 3,47 | 15,56 | -0,5 | 4,09 | 1,21 | 3,7 | 11,8 | 0,003 |
| USA | 3,7 | 2,53 | 17,97 | 0,37 | 3,31 | 2,45 | 9,94 | 135,9 | 0 |

**Table C.3.** Individual Countries Summary Statistics: Inflation Rate

| Gini | Mean | Median | Max. | Min. | Std. | Skew | Kurt. | J-Bera | Prob. |
|---|---|---|---|---|---|---|---|---|---|
| AUS | 43,67 | 43,45 | 47,43 | 40,98 | 1,34 | 0,36 | 3,29 | 1,27 | 0,53 |
| FIN | 44,34 | 44,52 | 46,11 | 42,84 | 0,82 | 0,02 | 1,94 | 1,55 | 0,46 |
| FRA | 41,36 | 42,36 | 44,66 | 35,92 | 2,63 | -0,45 | 1,76 | 3,7 | 0,158 |
| DEU | 43,75 | 44,09 | 45,26 | 41,52 | 0,95 | -0,44 | 1,99 | 2,77 | 0,25 |
| GRE | 44,48 | 43,68 | 49,93 | 39,41 | 3,53 | 0,17 | 1,5 | 3,58 | 0,167 |
| ITA | 48,45 | 48,28 | 54,25 | 44,49 | 2,5 | 0,57 | 2,59 | 2,49 | 0,288 |
| JAP | 40,73 | 42,27 | 44,96 | 34,14 | 3,27 | -0,76 | 2,24 | 4,82 | 0,09 |
| NLD | 51,81 | 52,1 | 55,93 | 47,04 | 2,83 | -0,28 | 1,65 | 3,22 | 0,2 |
| POR | 39,01 | 38,57 | 42,35 | 35,43 | 1,85 | -0,07 | 1,86 | 1,84 | 0,398 |
| ESP | 47,84 | 48,92 | 51,44 | 41,02 | 2,57 | -0,82 | 2,87 | 4,89 | 0,087 |
| GBR | 46,35 | 46,06 | 48,9 | 45,17 | 0,91 | 0,98 | 3,1 | 7,03 | 0,03 |
| USA | 46,64 | 46,94 | 50,61 | 41,48 | 2,63 | -0,55 | 2,19 | 3,01 | 0,222 |

**Table C.4.** Individual Countries Summary Statistics: Gini coefficient

| | Levels | | |
|---|---|---|---|
| Countries | pdebt | infl | gini |
| AUS | -2,3 | -3,49 | -2,59 |
| FIN | -1,69 | -3,79 | -2,9 |
| FRA | -1,36 | -3,37 | -0,98 |
| DEU | -0,68 | -5,35 | -1,91 |
| GRE | -1,57 | -4,32 | -1,28 |
| ITA | -0,62 | -1,83 | -1,65 |
| JAP | -2,28 | -3,79 | -2,14 |
| NLD | -0,31 | -3,9 | -1,92 |
| POR | -2,13 | -4,8 | -1,58 |
| ESP | -1,12 | -2 | -2,4 |
| GBR | -1,83 | -3,51 | -1,7 |
| USA | -1,04 | -3,56 | -2,17 |
| Critical Value | | | -2.89 |

**Table C.5.** Augmented Dickey Fuller Test for Unit Roots

| Countries | *Lag-Length* | | *Cointegration* |
|---|---|---|---|
| | *p* | *q* | |
| AUS | 1 | 1 | 0 |
| FIN | 1 | 1 | 2 |
| FRA | 2 | 1 | 0 |
| DEU | 1 | 1 | 1 |
| GRE | 2 | 1 | 0 |
| ITA | 2 | 1 | 1 |
| JAP | 2 | 1 | 1 |
| NLD | 2 | 1 | 2 |
| POR | 2 | 1 | 2 |
| ESP | 2 | 1 | 1 |
| GBR | 2 | 1 | 0 |
| USA | 2 | 1 | 0 |

**Table C.6.** Lag-Selection for Individual Countries and Cointegration Relationships

| Test for Weak Exogeneity of 5% Significance Level | | | | | |
|---|---|---|---|---|---|
| Country | F test | Fcrit (0.05) | pdebt | infl | gini |
| AUS | F(0,31) | | | | |
| FIN | F(2,29) | 3,33 | 0,26 | 0,25 | |
| FRA | F(0,31) | | | | |
| DEU | F(1,30) | 4,17 | 0,84 | 0,23 | |
| GRE | F(0,31) | | | | |
| ITA | F(1,30) | 4,17 | 0,05 | 0,63 | |
| JAP | F(1,31) | 4,16 | 0 | 0,71 | |
| NLD | F(2,29) | 3,33 | 0,37 | 0,25 | |
| POR | F(2,29) | 3,33 | 1,34 | 6,83* | |
| ESP | F(1,30) | 4,17 | 0,24 | 0,48 | |
| GBR | F(0,32) | | | | |
| USA | F(0,32) | | | | |

**Table C.7.** Weak Exogeneity Test for Foreign Variables