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Panagiotis Asimakopoulos

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Πατησίων 76, 104 34 Αθήνα. Τηλ.: 210 8203303-5. E-mail: econ@aueb.gr / www.aueb.gr
76, Patission Street, Athens 104 34 Greece. Tel.: (+30) 210 8203303-5

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Abstract

We adopted an empirical approach to capture the macroeconomic impact of tax changes for the examined period from 1974 to 2018. It is generally accepted that vector autoregression model (VAR) has proven useful for describing the dynamic interrelationships of multivariate series. Our empirical analysis focus on VAR models and Vector Error Correction Models to capture long term relationships Firstly, we apply a VAR (1,1) estimation that shows that the tax rate negatively affects GDP growth in the short run. The regression shows that a one percent increase in the tax rate lowers the level of GDP growth by 0,86%. Despite the fact that the results from VAR provide information on the short-run relationship between variables-in our case, it is crucial to know their long-run behavior. The VAR model passes diagnostic tests such as autocorrelation, heteroskedasticity, non-normality and stability. Also, we test for cointegration and we can conclude that VAR model is useful both in short and long run and we do not need to follow error correction methods. In addition, we conducted a Granger causality test to examine the causal relationship between GDP growth and tax rates. The test suggests that GDP growth has no causal effect on tax rate while tax rate has Granger causality with GDP growth. Moreover, the system equation results of VAR model confirms that tax rate are statistically significant for the GDP growth and coefficient for the lag of GDP growth are statistically significant for the current GDP growth. Thus, we confirm the null hypothesis that tax rate and lagged GDP growth is Grange causal with GDP. Also, the impulse response analysis is used to investigate dynamic interaction between tax rates and GDP growth. We find that a one standard deviation shock in the tax rate can lead to a substantial decline in GDP growth. This negative response continues to worsen through period 2. The response remains in negative region with an upward trend through period 3. The level of GDP growth remains in steady state through periods 5 to 10. It is critical to say that the above effects are for a one-time-only change, and would fade out to zero in the long run. The effects of a permanent change are given by the cumulative impulse response function which suggest 0,0025 decline of future GDP growth to one-unit upward shift in total tax rates. Moreover, from variance decomposition analysis we conclude that GDP growth is strongly endogenous in the long run while taxation policy is strongly exogenous in long run. It is obvious from our analysis that increases in tax rates have negative effect on output and economic growth. The model 1 confirms that tax rates and tax policy in the short-run, as a policy-making tool for overall economic growth, have a Granger causality effect on GDP for the period studied from 1974 to 2018, implying that the setting and structure of taxation is important not only for fiscal consolidation issues but also for the impact on economic development. In addition, we estimate vector autoregressive model 2, VAR (1,1), and examine the short run relationship among real GDP growth, personal income taxes, tax on goods and services, property taxes, debt, general government consumption expenditure, gross fixed capital formation and household consumption. Our estimation result suggests thar personal income taxes (-1,97%), tax on goods and services (-0,85%), debt (-0,19%), general government consumption expenditure (-0,54%), and household consumption (-0,65%) are negatively correlated with GDP growth while lagged GDP growth is positively correlated with GDP growth of current period (0,48%). Also, property taxes are positively correlated with gross fixed capital formation (3,62%), while debt is positively correlated with personal income tax (0,04%) and government expenditures with tax on goods and services (0,29%). The analysis of the coefficients suggests that income taxes were the most important factor in debt servicing, which had a negative impact on growth, and taxes on goods and services (transaction taxes) served mainly to address difficulties in government spending. Increased government spending and household consumption have a negative effect on growth and investment, while property taxes are positively correlated with investment in fixed assets. Government spending is negatively correlated with gross fixed capital formation (-0.14%). The VAR model passes diagnostic tests such as autocorrelation, heteroskedasticity, and stability test. Also, we test for cointegration we can conclude that VAR model is useful in short run while we conclude that we should apply error correction methods (VECM model 1) to capture long term relationships. Moreover, we estimate vector autoregressive model 3, as VAR (1,1) and examine the short run relationship among real GDP growth, debt, general government consumption expenditure and tax rates. Our estimation result suggests that debt (-0,19%), government spending (-0,88%) and the level of taxation (-0,77%) are negatively correlated with GDP growth while lagged GDP growth is positively correlated with GDP growth of current period (0,58%). VAR model 3 passes diagnostic tests such as autocorrelation, heteroskedasticity, and non-normality and stability. Also, we test for cointegration we can conclude that VAR model is useful in short run while we conclude that we should apply error correction methods (VECM model 2) to capture long term relationships. In this context, we conclude that policymakers should pursue a strategy that promotes the rationalization of government spending and the sustainability of debt, keeping the revenue capacity at a level that does not harm long-term growth.

JEL Classification: E6, H2

Keywords: VAR, VECM, Macroeconomic Impact

* The author is Ph. D candidate in Athens University of Economics and Business. Address: Athens University of Economics and Business, 76, Patission street, Athens 10434, Greece, e-mail: asimakop@aueb.gr

1.Literature Review

At first, we focus on a literature review that provides robust evidence on the relationship between tax policy and economic growth. To begin with, the negative impact of tax rates on growth has always been a crucial policy issue when it comes to, on the one hand, raising taxes to limit the budget deficit and, on the other hand, broadening the tax base and lowering tax rates as part of a growth-friendly tax reform. First, it is crucial to distinguish between the effects of measures aimed at both short-term effects and long-term growth. In the short run, both spending increases and tax cuts are likely to increase employment and output, as these effects work through the demand side of the economy. Direct spending and transfers generally have the largest impact on lower-income earners, while the smallest impact comes from tax cuts on high-income earners. Long-term increases, however, are a supply-side effect. In the long run, job availability is not a problem because the economy inherently creates jobs. Therefore, output can be increased through increases in labor productivity and hours worked, through increases in capital, and through changes in education and technological progress that increase productivity. In addition, labor supply can be increased or decreased by raising wages or lowering taxes. It is also well known that higher after-tax income theoretically encourages the consumption of more leisure time, which reduces labor supply, while the substitution effect encourages an increase in labor supply. In general, however, tax cuts still have similar effects to wages, as both income and substitution effects are quite small. The effects of taxes on saving and investment are also theoretically ambiguous. While substitution effects lead to a preference for future consumption, which increases saving, income effects mean that a given goal can be achieved with less saving because the after-tax rate of return is larger. However, investments in research and development are tax-advantaged because most research expenses are deductible when incurred. Another interesting aspect is the fact that taxes on capital gains are reduced over time due to changes in tax rates.

Numerous studies examined the role of taxes and their impact on economic growth not only in the context of endogenous growth models, but also in the context of the fiscal consolidation, output growth and government spending, and the impact of tax policy. One of the first attempts to study the impact of taxes on growth was by Solow (1956). According to the neoclassical development model, the break-even point of growth does not seem to be affected by tax policy. This means that the tax effect is so small that even if tax policy causes a reduction in product in some cases, it has no effect on the long-run growth rates of the economy. In contrast, more recent theories of endogenous growth, originally proposed by Romer (1986), develop models of economic development in which government spending and tax policy can have a long-run effect on growth. According to these models, taxes on capital and income taxes on individuals and corporations have a negative effect on growth. However, not all taxes cause the same changes, and the tax mix can be an important determinant of growth. Key studies include Barro (1990), Barro and Martin (1992), Engen and Skinner (1992), Easterly & Rebelo (1993), Alesina and Rodrik (1994), Stokey and Rebelo (1995), and Jones et al. (1993). Helms (1985) examined the relationship between tax increases and negative effects on economic growth, while Pecorino (1994) focused on the effects of tax reforms on the per capita growth rate. Koester and Kormendi (1989) examined economic growth in relation to the average tax rate and marginal tax rates. In particular, their analysis found that the impact of marginal tax rates on GDP per capita was significant. They concluded that a reduction in marginal tax rates of about 10% increases per capita income in a developed country by more than 7% if the mean tax rate remains constant. Also, a tax reform reduces tax progressivity, increases income and puts the country on an upward trend in economic growth. Overall, the studies of Marsden (1983), Manas-Anton (1987), Skinner (1987), Koester and Kormendi (1989), Martin and Fardmanesh (1990), Engen and Skinner (1992), Easterly and Rebelo (1993a), Easterly and Rebelo (1993b) showed a negative partial correlation between growth and the ratio of tax revenues to GDP and average and marginal tax rates. For a comparison of simulation results of growth effects on taxation in steady state, see Lucas (1990), King and Rebelo (1990), Kim (1992), Jones, Manuelli, and Rossi (1993), who compared growth effects with various parameters such as labor supply elasticity, tax rates, and depreciation of human and physical capital. In addition, Lehmussaari (1990) and Marsden (1990) and Trella and Whalley (1991, 1992) have shown that the combination of different taxes can have significant effects on savings, capital investment, and economic growth.

Barro (1991) also emphasized the positive relationship of education in human capital formation and the negative association of government reforms and economic development, while Plosser (1992) found a significant negative correlation between the level of taxes on income and profits as a percentage of GDP and the growth of GDP per capita. Similarly, King and Rebelo (1990), using an endogenous growth model, simulated changes in the income tax and found that an increase from 20% to 30% reduced economic growth by 2 percentage points. Easterly and Rebelo (1993), however, find that the level of taxes does not matter in regressions using new theories of economic growth. In fact, they claim that the reason Barro and Plosser found significant effects is because of the positive correlation between the level of taxes and the initial level of income, while pointing out that the ratio of taxes to GDP is relatively low in economically less developed countries. Devereux and Love (1995) examined the qualitative and quantitative relationship between taxation and output changes based on an endogenous growth model and concluded that income, capital, and consumption taxes tend to reduce growth. At the same time, Slemrod (1995) asserted a positive, negative, or no correlation between taxation and per capita income. In particular, Slemrod found a positive correlation between the level of central government tax revenues relative to GDP and the level of real GDP per capita in time series between 1929 and 1992 in the United States. In particular, when developing countries were included in the sample, a positive correlation was found between the level of tax revenues relative to GDP and the level of real GDP per capita. For OECD countries, Slemrod found no positive or negative correlation between the level of tax rates and the level of GDP per capita. However, he did find a negative correlation and examined the relationship between changes in tax rates or reasons for spending and growth in OECD countries.

Zee (1996), examining a sample of a total of 100 countries, 24 of which are members of the OECD, compared the tax revenues of developed and developing countries and concluded that the statistical correlation between economic growth and the level of taxation is not significant for all groups of countries except the recently industrialized countries. Three years later, using a sample of seven Asian countries, Kerr and MacDonald (1999) found that a causal relationship between the logarithms of the economic and tax variables exists only in some of the countries considered. Also, Widmalm (2001) found that economic growth was positively related to corporate income tax and negatively related to personal income tax, while he found gross results for property, goods and services, and payroll taxes. More recent contributions such as that of Tosun and Abizadeh (2003) point out the negative relationship between payroll, goods and services taxes and GDP per capita, while on the contrary they find a positive relationship between personal and property taxes and economic growth. In the same context, Gordon and Li (2005) focus mainly on the impact of tax structure on economic growth, using data for 70 OECD member countries over the period 1970-1997. They conclude that a 10% reduction in the corporate tax rate can increase the annual growth rate by 1.1%. Also, Anastasiou and Dritsaki (2005) examined the relationship between tax revenues and economic growth for Greece. Using annual data for the period 1965 to 2002, they find that there is a one-way causal relationship between the direct tax rate and the economic growth rate, but also between tax revenues and the country's economic development. In another similar study, Dritsaki et al. (2005) examine the relationship between the different tax categories and economic growth in Greece using cointegration analysis. They conclude that there is a long-run relationship between GDP per capita, the openness of the economy and the different tax categories, while they find that there is a one-way causality between market openness and the corporate income tax and between the payroll tax and GDP per capita. Myles (2007), in his theoretical analysis of the impact of tax policy on economic development, points out that lower tax rates, broadening of the tax base, and higher tax consumption relative to income tax are reforms that promote development. Johansson et al. (2008) argue that income taxes, extraordinary property taxes, and consumption taxes are significant barriers to economic development. Arnold et al. (2011), in a sample of 21 OECD countries over the period 1971-2004, found that tax revenue was negatively related to GDP per capita, while a shift from direct to indirect taxation was positively and significantly related to GDP per capita. Estimates from the model also indicated that taxes on real estate and excise taxes are more business-friendly than personal and corporate income taxes, which make them more harmful.

Another endogenous growth model was developed by Barro (1990), who examined the role of taxes and their relationship with economic growth, including tax-financed policies implemented by the government to affect output . In addition, E. Engen and J. Skinner (1992) examined the impact of tax policy on economic growth. Government fiscal policy can have two opposite effects on an economy. More specifically, taxation, which finances public spending, causes distortions in the economy, while tax revenues are used to provide public goods and infrastructure. Based on this concept, the authors develop a generalized model of fiscal policy and product growth to determine the impact of fiscal policy on the economy. Examining data from 107 countries for the period 1970 to 1985, they conclude that fiscal policy is negatively correlated with economic growth in both the short and long run. In particular, they estimate that a 10% tax increase will lead to a 3.2% per year reduction in the growth rate in the short run. Correspondingly, a 10% increase in taxes and public spending (to keep the government budget balanced) lead to a 1.4% per year reduction in the growth rate of the economy in the long run. This shows that both public spending and taxation have negative effects on economic growth. They also highlight the role of the structure of tax systems, arguing that tax systems based on a small tax base and levying high taxes cause more distortions in the economy than tax systems levying the same amount of taxes but on a larger tax base. Finally, they point out that although the impact of the income tax on labor may be different than that of the corporate income tax, this does not negate the important role that tax policy. Overall, they find that increases in government spending and taxation are likely to reduce output growth rates when the budget is balanced. Easterly & Rebelo (1993) examined the empirical regularities that exist between taxes, fiscal policy variables, the level of development, and the growth rate. Stokey and Rebelo (1995) examined which parameters of the endogenous growth model are crucial for determining the impact of tax reform from a quantitative perspective. Among other things, they conclude that the crucial parameters are depreciation rates, the elasticity of intertemporal substitution, and the elasticity of labor supply, while the elasticity of substitution in output is relatively insignificant, and note that recent estimates of the potential growth effects of tax reform vary widely, ranging from 0 to 8 percentage points. Pecorino (1994) noted that replacing the income tax with a consumption tax will lead to a 1% increase in per capita growth per year. Similarly, replacing capital taxation with a higher tax on labor income will lead to a slight decline in economic growth, as shifting the burden from capital to employment will create distortions in the relationship between capital and labor in production.

Mendoza et al. (1994) proposed a methodology for calculating effective tax rates and pointed out important international differences in implemented tax policies[1]. Alberto Alesina and Dani Rodrik (1994) examined the relationship between policy and economic growth using a simple model of endogenous growth that takes into account tax policy redistributive effects between capital and labor and welfare effects. More specifically they attempted to determine whether inequality is indeed a statistically significant indicator of long-run growth. The extent of inequality is indicated by the Gini index. Their sample consists of 54 countries for the period 1960 to 1985, and the results of their regressions show that income inequality is negatively associated with economic growth. In fact, the relative rate is statistically significant at the 5% confidence interval, while the t-statistics for the Gini index and the R-squared are impressively high. L. Stokey and S. Rebelo (1995) conducted a study in which they used an endogenous growth model to assess which factors are important for the impact of tax reform on the long-run growth rate of the economy. In particular, they examined the introduction of a proportional tax on income from natural and human capital. Finally, they pointed out that even if the impact of the reform is small on economic growth, this is not necessarily true for the corresponding impact on citizens' welfare. Alesina and Perotti (1995) also examined the expansion of the government budget, with debt, fiscal policy, and the effects of tax policy being key determinants, while Engen and Skinner (1996) examined the growth effects following the implementation of a major tax reform. Specifically, Alesina and Perotti (1995) examined

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[1] For relevant studies of effective tax rates, see Martinez-Mongay (2000), Carey and Tchilinguirian (2000), and Carey and Rabesona (2002), which focus on a sample of OECD countries over the period 1975-2000. Trabandt and Uhlig (2011) provide a database of effective tax rates for several EU countries and the United States, while Papageorgiou et al. (2012) compare Greece with the rest of the euro area. See also McDaniel (2007). Dellas et al. (2017). For euro area and Greek effective tax rates, see Kollintzas, Papageorgiou, and Vasilatos (2010). Papageorgiou et al. (2011) find that despite high statutory tax rates, effective tax rates in Greece are much lower than in the euro area, suggesting high levels of tax evasion and avoidance.

budget expansions and adjustments in OECD countries over the past three decades by providing a critical overview of the political-institutional determinants of government budgets and discussing the policy implications for public debt accumulation, fiscal imbalances and adjustments, and tax policy. In addition, Engen and Skinner (1996) advocate modest effects of 0.2% to 0.3% difference in growth rates in response to a major tax reform that changed marginal tax rates by 5 percentage points and average tax rates by 2.5%. In this context, small effects can lead to a large cumulative effect on living standards and economic growth. To support this thesis, they took three approaches. First, they examined historical data from the United States to estimate the magnitude of the impact of tax cuts on economic growth. Second, they examined substantial evidence on taxation and growth for a large sample of countries, and finally, they used evidence from micro-level empirical studies of labor supply, investment demand, and productivity growth.

In addition, J. Agell, T. Lindlh, and H. Ohlsson (1996) examined the relationship between economic growth and the size of the public sector in the context of a trade-off between the negative effects of imposing higher taxes and the positive effects of public investment and government intervention. In these models, the government faces a maximization problem. On the point, the positive impact of its intervention on the growth rate must equal the negative impact of taxation. Using a theoretical model, they show that endogenous development models emphasize the importance of the public sector but are not clear enough about their precise impact on the rate of economic growth. They then use data from 23 OECD countries for the years 1970 to 1990, referring to average annual growth rates in terms of GDP per capita and average tax revenues as a percentage of GDP. The higher the share of tax revenues in GDP, the larger the public sector in a country, and therefore more resources are needed to finance it. The empirical study concludes that it is not possible to demonstrate a clear relationship between economic growth and the size of the public sector.

Jang-Ting Guo and Kevin J. Lansing (1997) examined the effects of the structure of the tax system on the welfare of the economy in the context of an excellent fiscal policy model. In particular, they seek to examine the effects on welfare of two features of the tax system. First, the extent to which depreciation reduces taxation and the differential tax treatment of labor and capital income. In the first part, they develop a theoretical model based largely on Ramsey's (1927) model. In solving the model, they find that the household's long-run wealth (as measured by its steady-state wealth) can be improved by an accelerated depreciation policy in which the depreciation rate for tax purposes exceeds the economic depreciation rate. Moreover, they quantify the theoretical model they constructed to measure wealth, product, and tax levels in the steady state. Finally, the authors show that accelerated depreciation policies can mimic the features of a tax on corporate profits without reducing welfare. They also find that the different treatment of labor and capital income in the case of a standard depreciation tax policy has little effect on long-run welfare

Mendoza et al. (1997) provided both theoretical and empirical evidence on how tax changes significantly affect investment and long-run growth. They concluded that the investment rate increased by 1.8% (1.0%) after taxes on labor (capital) were reduced by 10 percentage points. Gemmell et al. (1999) used endogenous growth models to examine how the tax structure and public spending affect the steady growth rate. Their results for a panel of OECD countries suggest that higher distortionary taxes lead to lower GDP growth rates and vice versa; in particular, their estimates suggest that a 1% increase in distortionary taxes (as a percentage of GDP) would lead to a 0.1-0.2% decline in GDP growth. Myles (2000) assesses the theoretical and empirical evidence on how taxation affects the rate of economic growth. Myles (2000) noted the significant contribution of endogenous growth models to the study of the tax effects of an economy. However, the theoretical models isolate a number of channels through which taxation can affect the growth rate. The goal of his study is to identify these channels and determine the extent to which they ultimately affect economic growth. According to the author, these channels include factors such as the openness of the economy, the process of human capital formation, the elasticity of utility functions, and the depreciation rate. In an open economy, factors of production can migrate if taxes are high. As a result, this economy lacks resources that could help increase its output. The conclusion of his empirical study is that while these factors are channels for the diffusion of the effects of taxation, these effects appear to be of little importance. According to Myles, the empirical study leads to a very important guideline: the structure of the tax system, i.e., the tax policy mix, is more important than the level of taxation. When growth is endogenously caused, taxation affects the factors of the economy, which in turn affect the growth rate. Therefore, in designing the optimal tax, a balance must be struck between the elasticity of demand and the impact on the growth rate to minimize distortion of decisions. Ideally, taxation should be imposed primarily on goods with inelastic demand that have little impact on growth. In addition, taxation should be designed so that it does not create major distortions in the decision to educate (it does not negatively affect expectations for future returns).

Myles (2009) also points out that economic growth must be viewed as the foundation for greater prosperity and that the relationship between sustainable growth and taxation is an important goal for policymakers. In addition, Steven P. Cassou and Kevin J. Lansing (2003) examined the impact of changing the tax system from progressive to proportional on growth. They concluded that the transition from a progressive to a proportional tax system affects decisions about consumption, work, learning, and investment, which in turn affect the rate of economic growth. The parameters of labor supply elasticity and the share of physical capital in the product play an important role in this process. Also, they quantified the model and present their predictions regarding the expected growth rate and the time it will take the economy to adjust to the new tax system. Their model predicts that a change in the tax system could produce a permanent increase in per capita growth from 0.009% to 0.143%. The period required for the post-reform product to exceed the pre-reform level is estimated at 6 years. This is due to the additional capital accumulation caused by the changes in the tax code. The most important component through which the tax reform can boost growth is the introduction of a single marginal tax rate. However, this reform initially slows growth because a higher new tax rate must be introduced to keep tax revenue unchanged. Daveri and Tabellini (2000) examined the impact of the tax rate on the level of unemployment and economic growth. First, an increase in taxes on labor leads to a reduction in labor demand and thus to unemployment, and second, the marginal product of capital falls in the long run, reducing the incentive to invest and grow Widmalm (2001) examined the impact of the tax structure on growth using cross-sectional data for three OECD countries over the period 1965-1990. Despite the limitations of using only three OECD countries, the following methodology was adapted from Levine and Renelt (1992)**,** but uses four basic variables, namely income, the ratio of investment to GDP, population growth, and the average tax rate [2]. They found that the share of personal income tax in total tax revenue has a negative and robust correlation with growth, and another point was to show that progressivity affects growth. By using data from 23 OECD countries for the period 1965 to 1990, it is found that the structure of taxes affects a country's economic growth. In particular, the use of an econometric model leads to the following conclusions. First, different types of taxes have different effects on economic growth; second, a high degree of progressivity is associated with lower growth because it reduces the returns to human and physical capital; its impact on economic growth is negative because it distorts individuals' decisions about how much to work and how much time to devote to education; and fourth, there is evidence that consumption taxes promote economic growth.

Padovano and Galli (2001) propose refined econometric estimates of effective marginal tax rates and conclude that they are negatively correlated with economic growth for a data set of 23 OECD countries. In particular, they argue that it is better to use the marginal effective income tax rate rather than the average rate to measure the impact of taxation on economic growth, which has led previous research to conclude that there is no significant correlation between economic growth and taxation. The authors use data from 23 OECD countries for the period 1951 to 1990. To calculate the marginal effective tax rate, each country relates its total annual tax revenue to its annual gross domestic product. Having improved the estimation of the effective marginal tax rate using this sample, they succeed in isolating its impact on economic growth. Their analysis shows that high marginal tax rates and the progressivity of the tax system are negatively correlated with economic growth, which is inconsistent with the results of previous studies. Gale and Potter (2002) evaluated EGTRRA and conclude that its implementation has negative effects on growth and fiscal sustainability, as well as on interest rates and fiscal complexity. In addition, Li and Sarte (2004) examined the effects of progressive taxes on heterogeneous growth models. In the first part of their study, the authors construct a theoretical endogenous growth model that theoretically describes the design of tax policy. This is an endogenous growth model in which households maximize their wealth function subject to their income constraint and firms maximize their profit function. In each period, the government chooses the tax rate that balances its budget and imposes taxes to finance government spending. The progressivity of a tax is determined by the ratio between the marginal tax rate and the average tax rate. In practice, this is the case when the marginal tax rate is higher than the average tax rate for each income level. In the second part of their study, they attempt to quantify the changes in the U.S. economy caused by the TRA -86 tax law. The results of their study are as follows: First, a decrease in progressivity leads to an increase in long-run growth from 0.12% to 0.34%; second, a decrease in progressivity leads to a 20% increase in income inequality with a 24% increase in the Gini index; and third, they prove that the tax-to-income ratio can be a

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[2] First, the share of the various tax categories in total revenues was considered (corporate income tax, personal income tax, property tax, taxes on goods and services, and payroll tax)

misleading indicator of tax policy because it only reflects average taxation and does not take into account the effects of differentiating progressivity.

In addition, Lee and Gordon (2005) examined how tax policy affects a country's growth rate, and Tosun and Abizadeh (2005) empirically examined the correlation of tax changes in personal, property, service, and payroll taxes with GDP per capita and economic growth. Lee and Gordon (2005) examined how tax policy affects a country's growth rate. Lee and Gordon (2005) conducted a tax regression using the top marginal corporate tax rate and the top marginal personal tax rate to capture the effects of taxation. In particular, they concluded that corporate taxes are most detrimental to growth because they adversely affect entrepreneurial activity and provide a disincentive to innovation. In addition, Lee and Gordon (2005) use cross-country data from 1970-1997 to examine how tax policy actually affects a country's growth rate. They find that statutory corporate tax rates are significantly negatively correlated with economic growth rates. Specifically, GDP growth increases by 1 to 2 percentage points after a 10% reduction in the corporate tax rate. Their study relies primarily on the predictions of economic theory about the effects of taxes on the economy, such as the negative relationship between taxation and capital accumulation in the neoclassical model, continuous growth under stable taxation in endogenous growth models, and the negative effects of taxation on risk-taking business decisions. On this basis, they begin their empirical analysis with a sample of 70 countries with data from 1970 to 1997 to examine the impact of tax policy on a country's growth rate. Using econometric models to analyze these data, they reach the following conclusions. First, corporate tax rates exhibit a particularly negative correlation with economic growth, which is fully consistent with the predictions of economic theory. Then, their estimates show that a 10% reduction in the corporate tax rate can lead to a 1.1% increase in the annual growth rate, which facilitates corporate decision making and risk taking. In addition, lower corporate tax rates lead to lower corporate tax revenues because lower taxes motivate more people to become entrepreneurs. Finally, they show that several tax variables, such as the average tax rate on labor income, are not significantly associated with the economic growth rate. Tosun and Abizadeh (2005) empirically examined tax changes in a dataset of OECD countries in response to GDP per capita from 1980 to 1999 and found that economic growth had a significant impact on OECD countries' tax policies, showing that different taxes respond differently to GDP per capita. In particular, personal and wealth taxes responded positively to economic growth, while payroll taxes and goods and services taxes showed a negative correlation.

Pjesky, (2006) examined the relationship between the corporate income tax and economic performance and concluded that the top tax rate has little effect on income and employment, while Marcellino, (2006) focused on a set of stylized facts about tax policy and the effectiveness of fiscal and monetary policy. Bania et al, (2007) studied the linear incremental effect of taxes on fiscal policy in the U.S., while Reed, (2008) estimated the negative relationship between taxes and income growth using U.S. data from 1970-1999. The result showed that taxes used to finance general expenditures are associated with significant, robust negative effects on income growth. Arnold (2008) examined the relationship between the composition of taxes and economic growth and concluded that income taxes are generally associated with lower economic growth than consumption and property taxes. In a 2008 OECD study, Arnold attempts to classify the different types of taxes according to their impact on the economy. It is a fact that taxes create distortions in the economy but are necessary for government to function. However, the extent of distortions caused may depend on the structure of the tax system or the tax policy mix and not necessarily on the tax burden. The study uses data from 21 OECD countries for the years 1971 to 2004, which it regresses. The results of the regressions show that property taxes, especially recurrent property taxes, are the most growth-friendly taxes, followed by consumption taxes. In addition, income taxes are generally associated with lower growth rates than property and excise taxes. Finally, corporate income taxes appear to have the most negative impact on GDP per capita. Thus, tax-neutral tax reform aimed at increasing GDP per capita requires a shift to property and consumption taxes and the avoidance of income taxes and, in particular, taxes on corporate profits.

Also, K. Angelopoulos, J. Malley, A. Philippopoulos (2008) examined the quantitative effects of a change in tax composition on the long-run growth and expected lifetime utility of the UK economy for the period 1970-2005. In the first part of their study, they construct a dynamic general equilibrium model in which human capital accumulation is the engine of growth, drawing on the corresponding model of Lucas (1990), which they extended by allowing for the presence of externalities due to human capital accumulation, the imposition of a consumption tax, uncertainty, and public investment. The economy consists of many identical households and firms. Households seek to maximize their timeless wealth. Firms produce a homogeneous product using private physical capital, labor, and public infrastructure. The government has tax revenues from capital, labor, and consumption taxes, which it uses to finance public consumption, public infrastructure, public education, and transfer payments. In solving the model, they conclude that the impact of tax reform on economic growth can be small, while the impact on welfare can be substantial. In particular, their results suggest that if the goal of tax policy is to increase long-run growth by changing the relevant tax rates, taxes on labor should be reduced while taxes on capital or consumption should be increased to balance the government budget. Conversely, if tax policy is to increase welfare, it must reduce taxes on capital and increase taxes on labor or consumption. Moreover, the second part of the study quantifies the effects of the above tax reform. Specifically, for the first case, they find that if the tax rate on labor is reduced by 10%, the net growth rate increases by 2.43% (if the tax on capital is increased at the same time) or by 2.42% (if the tax on consumption is increased at the same time). For the second case, they find that increasing welfare by lowering the capital tax rate by 10% and simultaneously increasing the labor tax rate will result in a further 1% annual increase in consumption, while lowering the capital tax rate by 10% and increasing the consumption tax rate will increase annual consumption by 1.5%.

Arnold et al. (2011) identified fiscal policies that both accelerated the fiscal recovery and contributed to long-term sustainable growth. According to this approach, short-term recovery requires an increase in demand, while long-term growth requires an increase in supply. Since short-term tax relief is difficult to reverse, the measures implemented could be detrimental to long-term growth. The above analysis uses evidence on the impact of the tax structure on economic growth to identify which growth-friendly tax changes can also support recovery and social cohesion. Specifically, the question is what might be the right fiscal policy mix to ensure both the short-term recovery of an economy from the recent financial crisis and the achievement of long-term growth. It is also known that short-term recovery is achieved through the demand channel, while long-term economic growth requires an increase in supply. The analysis focuses mainly on the structure of taxes (e.g., the tax policy mix) rather than the level of taxes in each country. To analyze the impact of the tax policy mix, the authors collected data from the OECD database for 21 countries for the period 1971-2004. With these data, they build an econometric model whose basic equation includes GDP per capita as the dependent variable and investment in natural and human capital, population growth, tax indicators, and a contemplative term as independent variables. They assume that any change in tax rates is such that total tax revenues remain unchanged (revenue-neutral tax shifts). The regression results show that the following taxes have the least impact on long-run GDP per capita growth: recurring taxes on immovable property, excise taxes, personal income taxes, and corporate income taxes. With respect to short-term economic recovery, they point out that tax cuts on corporate income and profits would have little impact on short-term growth. The authors draw the conclusion that a gradual shift to property taxes and consumption taxes may lead to economic growth, but a cut in the corporate tax or a reduction in the maximum personal income tax rate is unlikely to accelerate growth and recovery from an economic crisis. One tax reform that can contribute to both long-term growth and short-term economic recovery is a cut in income tax (including social security contributions) for low-wage earners, as this will boost demand, increase incentives to work, and reduce income inequality.

Moreover, Gemmell et al. (2011) point out that the estimated long-run growth effects of fiscal policy tend to be achieved quickly, which is consistent with empirical results from short-run models. Ferede and Dahlby (2012) also examined the effects of tax rates on economic growth and found that a higher statutory corporate tax rate is associated with lower private investment and slower economic growth, while a reduction in the corporate tax rate has a statistically significant positive effect on the growth rate. Their empirical estimates suggest that a 1% reduction in the corporate tax rate is associated with a 0.1% to 0.2% increase in the annual growth rate. In the same context, McBride (2012) and Huang and Frentz (2014) have highlighted that it is relatively unclear whether tax cuts promote growth when applied as non-exogenous changes in tax policy. Hungerford (2012) also attempts to explore whether or not there is a relationship between the level of tax rates and taxpayer income with economic growth, long-term debt reduction, and productivity.

In addition, Gravelle (2014) summarizes evidence on the relationship between tax rates and economic growth by outlining the framework of tax reforms and indicating whether broadening the tax base or changes in tax rates have an impact on the economy. Gemmell et al. (2014) also concluded that direct taxes tend to hurt economic growth because the tax impact on GDP is largely through factor productivity rather than factor accumulation. Gale and Samwick (2014) argue that the positive effects of tax cuts are offset by negative policy changes, which include subsequent tax increases or cuts in government spending to reduce government debt and deficits. Gale et al. (2015) find that neither tax revenues nor top income tax rates in U.S. states have a stable relationship with economic growth or employment, while Li and Lin (2015) analyzed the impact of the sales tax on economic growth in the United States over the 1960-2013period and find that economic growth is negatively related to the sales tax in the long run but has a positive impact in the short run.

Akgun et al. (2017) also showed that lowering corporate and personal income taxes while raising taxes on recurrent wealth and consumption could increase GDP growth. Galindo (2011) and Blochliger (2015) study that taxes on corporate or personal income reduce incentives to increase supply, while property tax has no disincentive effect. Jelena et al. (2018) provide econometric models to estimate the tax impact on economic growth using a panel of OECD countries, while Karras (2019) examines the macroeconomic impact of tax changes by showing that changes in the tax rate have temporary effects on the real growth rate but permanent effects on the level of output. Zidar (2019) examines how tax changes affect aggregate activity for different income groups. Alinaghi (2021) conducts an analysis of the impact of taxes on economic growth in OECD countries when part of the tax package is taxed positively or negatively. The main finding is that a 10% tax increase is associated with a decline in annual gross domestic product (GDP) growth of about -0.2% in the case of a negative tax package.

Regarding dynamic modeling, it should be noted that prominent examples of VAR approaches include Blanchard and Perotti (2002), who studied the dynamic effects of shocks in government spending and taxes on economic activity in the U.S. in the postwar period using a mixed structural VAR approach. Using quarterly U.S. data from 1960 to 1997, the authors find what passes for stylized fact: an increase in government spending has a statistically significant positive effect on output, while an increase in taxes has a significantly negative effect. Also, both tax increases and increases in government spending have a strong negative effect on investment spending. Similarly, Barro and Redlick (2011) examine tax multipliers for U.S. annual data including World War II, focusing on changes in defense spending and other components of GDP, particularly investment, and show that increases in average marginal tax rates had negative effects on GDP. Perotti (2002) examined the effects of fiscal policy on GDP, prices, and interest rates using a structural VAR model.

Alesina et al. (2018) also examine the impact of fiscal adjustments on output, while Mertens and Olea (2018) use the ProxySVAR model together with the instrumental variable method for local projections[3], to examine the macroeconomic effects of changes in marginal tax rates on output and unemployment. They conclude that reductions in marginal tax rates have positive effects on output and negative effects on unemployment. Alan et al. (2021) apply an SVAR to U.S. federal spending, revenue, and GDP to examine the effects of tax shocks. In addition, Mountford and Uhlig (2002, 2009) examined the effects of fiscal policy on U.S. data using vector autoregressions and conclude that the best fiscal policy to stimulate the economy and improve GDP appears to be a deficit-financed tax cut. Hussain and Malik (2016) use the ProxySVAR methodology and, applying the identification strategy of Romer and Romer (2010), find that tax cuts have a positive and significant effect on output. Afonso and Sousa (2012) examined the macroeconomic impact of fiscal policy using a Bayesian Structural Vector Autoregression (B-SVAR)

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[3] Using new narrative measures of exogenous variation in marginal tax rates associated with postwar tax reforms in the United States (1946-2012); see also Jordà and Taylor (2016), Fieldhouse et al. (2017), Stock and Watson (2018), Mertens and Olea (2017), Ramey and Zubairy (2018)

approach and conclude that government spending shocks generally have a negative impact on GDP.

A newly built up method for measuring the macroeconomic impact of tax changes was the narrative approach[4] . This method relies on legislative acts to identify tax shocks and estimate their macroeconomic impact. This approach has been used extensively to estimate the effects of monetary policy in Romer and Romer (1989, 2004), government spending in Ramey and Shapiro (1998) and Ramey (2011), and for fiscal consolidations in Guajardo et al. (2011). First, Romer and Romer (2010) examined the impact of tax changes on economic activity by using the record to identify the size, timing, and main reasons for all major tax policies in the postwar period. Therefore, their analysis facilitates the distinction between legislative changes that were due to economic activity and those that were made for exogenous reasons. Thus, using an autoregressive distributed-lag model of output growth with their tax shock series as the independent variable, they find that tax changes can have significant effects-an exogenous tax increase of 1% of GDP lowers GDP by almost 3% over the medium term. Similarly, Favero and Giavazzi (2009) estimate tax multipliers by plotting differently the time series constructed by Romer and Romer for tax changes in the U.S., including output, government spending and revenue, inflation, and the nominal interest rate. Also, Favero and Giavazzi (2010, 2012) reconcile evidence of tax shocks in VAR and shocks obtained using the narrative method. In an application of the narrative approach to the United Kingdom, Cloyne (2011) finds results very similar to the original work for the United States-a tax increase of 1% of GDP lowers GDP by 2.5% over three years. Devries et al. (2011) focus on discretionary changes in taxes and government spending. Perotti (2012) also argues that, from a theoretical perspective, the discretionary component of taxation should be granted different effects than the automatic response of tax revenues to macroeconomic variables.

Alesina, Favero, and Giavazzi (2012) emphasize that the main advantages of the narrative approach lie in the distinction between different shifts in fiscal policy and between anticipated and unanticipated components of fiscal policy shocks, which is important to avoid biases in the estimation of fiscal multipliers. Guajardo et al, (2014) examine the short-run effects of fiscal consolidation on economic activity in OECD economies by identifying changes in fiscal policy that are motivated by a desire to reduce the fiscal deficit rather than by a response to prospective economic conditions. In addition, Mertens and Ravn (2013) estimated the dynamic effects of tax changes in the United States by developing a new narrative representation of changes in federal tax liability on personal and corporate income. They showed that a 1% reduction in the average personal income tax rate increases real GDP per capita by 1.4% in the first quarter and by as much as 1.8% after three quarters. Similarly, the same decrease in the average corporate tax rate increases real GDP per capita by 0.4% in the first quarter and by 0.6% after one year. Also, Cloyne (2013) provided new estimates of the macroeconomic impact of tax changes using a new narrative dataset for the United Kingdom using the Romer and

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[4] As a rule, the narrative approach has appreciated greater multipliers. Favero and Giavazzi (2012) and Perotti (2012) discuss and compare the two approaches in detail. For narrative tax datasets, see Romer and Romer (2010), Cloyne (2013), Uhl (2013), Lopes (2015), Pereira and Wemans (2015), Gechert et al (2016), Gil et al (2018), Loate et al (2021) for country-specifics. For cross-country, see Devries et al (2011), Alesina et al (2015, 2017), Gunter et al (2019), David and Leigh (2018). For the identification problem in narratives and VAR, see Leeper (1997).

Romer narrative strategy and found that a 1% tax cut increases GDP by 0.6% in the first quarter and by 2.5% over three years. Guajardo et al. (2014) examine the short-run effects of fiscal consolidation on economic activity in OECD countries by examining contemporaneous historical records. In addition, Romer and Romer (2014) examined the incentive effects of marginal tax rates in the United States during the interwar period. Mertens and Ravn (2014) also use narrative measures as proxies for structural shocks to total tax revenues in an SVAR and estimate tax multipliers. Nughen et al. (2016) find that income tax shocks have large short-run effects on GDP, private consumption, and investment. Gunter et al. (2017) estimate the impact of global VAT changes on output using the narrative approach. Kato et al. (2018) use the narrative approach to identify tax changes unrelated to current economic conditions and estimate the impact of these changes on macroeconomic variables during and outside the zero lower bound periods in Japan.

Dabla-Norris and Lima (2018) build a new narrative dataset of tax changes to analyze the macroeconomic impact of tax changes in years of fiscal consolidation, distinguishing between tax rate and tax base changes and, moreover, between personal, corporate, and value-added tax changes. Hebous and Zimmermann (2018) found that narrative tax measures are only weakly correlated with cyclically adjusted tax revenues for the U.S. and the U.K., while Cloyne et al. (2018) apply a narrative study to examine the impact of tax policy on economic activity in the U.K. and find that tax changes have a significant impact on GDP, with impact multipliers around 0.5 and exceeding 2 within two years. Nguyen et al. (2020) estimate the macroeconomic impact of exogenous changes in income and consumption taxes using narrative tax shocks to changes in tax liability in the United Kingdom. Wan der Wielen (2020) examines the macroeconomic effects of anticipated and unanticipated tax changes in the European Union between 2000 and 2016 and provides narrative panel estimates of output and employment multipliers for tax changes.

2. Data and Methodology

At this point we assess the macroeconomic impact of Greek Tax system[5]. To capture the dynamic relationship between tax rates and macroeconomic variables, our multivariate data analysis is conducted within the framework of vector autoregressive models and vector error correction models. We begin by creating the dataset that we will use for our empirical analysis. In terms of variables, the total tax revenue-to-GDP ratio is defined the total tax revenue as a percentage of GDP (TAX RATE) and applied to annual real GDP growth (GDP) to examine the overall effect of taxation on economic growth. Thus, at first place, we apply a general VAR model that enables us to estimate the impacts of total tax rate on economic growth. In addition, instead of looking only at the GDP

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[5] All data from the OECD and The Conference Board Total Economy Database, the IMF, and AMECO covered the period from 1974 to 2018 and expressed as percentage or percentage/GDP. We remove trend information from time series by detrending (differentiating) and we also use lagged growth.

growth and bearing in mind that taxes is not the only factor for economic growth, we also examine the relationship on other macroeconomic variables such as gross fixed capital formation (GFCF) as a proxy for investment, government consumption expenditure (GGCE) and household consumption (HSCONS) which are expressed as percentage of GDP. Having in mind, the crucial role of debt sustainability we also include debt (DEBT) in our analysis. In addition, another extension is the partial decomposition of tax revenues. More specifically, we focus on personal income tax (PIT), tax on goods and services (TOGS) and property taxes (PT) and their impact. Furthermore, we assess the dynamic relationship between total tax rate, government expenditures, debt and GDP growth. Data are already percentages or percentage of GDP so there is no need for log transformation.

Table 1 presents briefly descriptive statistics as well as Figure 13 shows the plot of level and difference graphs which suggest that most series show a trend, while the presence of structural breaks is also evident. Moreover, we can clearly see that the first difference of the variables is stationary and that have mean reversion, which means that oscillates around zero [6]. Before we perform the VAR estimation, it is important that we conducted a diagnostic estimation for the research variables. The first test that must be performed is the stationary test to assess the presence of unit roots in the variables. More specifically, the test is performed using the Augmented Dickey Fuller test which uses both the intercept and trend structure of the data to test the null hypothesis that a unit root is present on a time series. From the Table 2, the Augmented Dickey-Fuller test shows that variables (except for GDP growth) are nonstationary in their level form for both the intercept and trend terms. Consequently, they exhibit a unit root in their level form. However, all variables became stationary after their first difference was taken. Therefore, all research variables are stationary at l (1) and do not have a unit root in their trend and intercept structure. When the time series are not stationary, we generally take differences of the data to make them stationary, and then fit a model VAR and is estimated using the principle of least squares. In this way, the time series are adjusted for an underlying trend and seasonal or cyclical effects are more easily captured. The adjustment is made through differencing[7] them except for GDP growth, which is stationary, but we used lagged growth to remove a time-varying mean as well as control for historical factors that might directly affect GDP growth in the current period. Nevertheless, by differentiating the time series eventually make them stationary, but we experienced the cost of ignoring possible long-term relationships between levels. As far as cointegration is concerned, a usual approach is to use the Johansen method to test whether or not there is cointegration [8].In the presence of cointegrated series we use VECM to capture a long-term relationship between

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[6] A stationary time series oscillates around its mean μ and has a constant variance for all t. However, many economic series exhibit upward (or broken) trends over time. There are two approaches to capturing these trends. The deterministic trends (trend-stationary) and the unit root process (first-difference process - integrated of order d=1 - I (1))

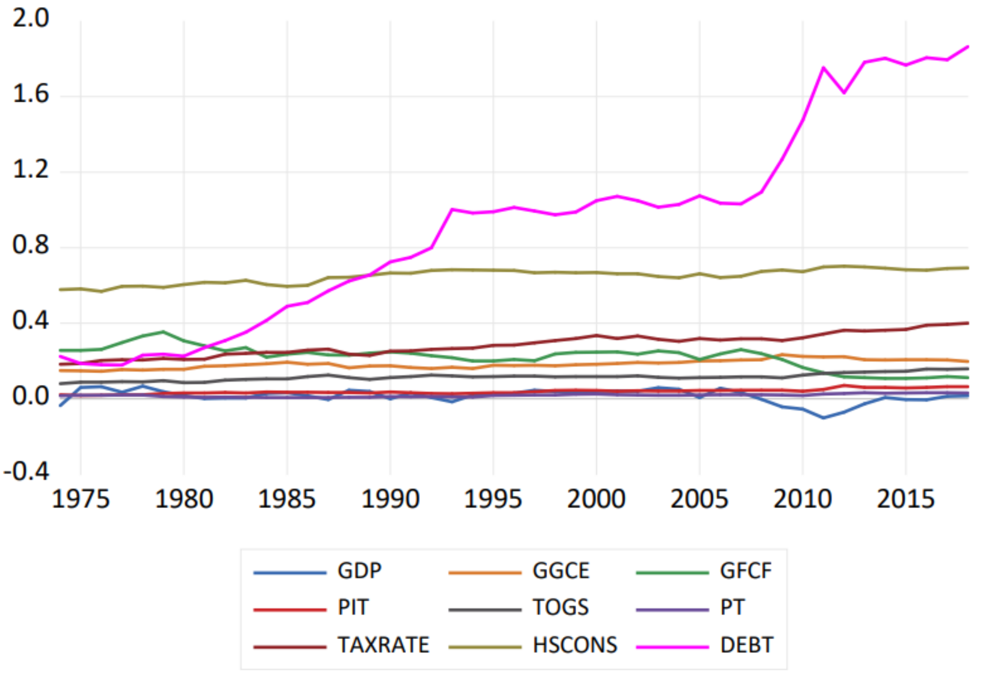
[7] By doing this, overall upward trend has been removed. Stationary differences and stationary cointegrated relationships between non-stationary variables allow us to analyze economic data as short-term variations around moving long-term equilibria.

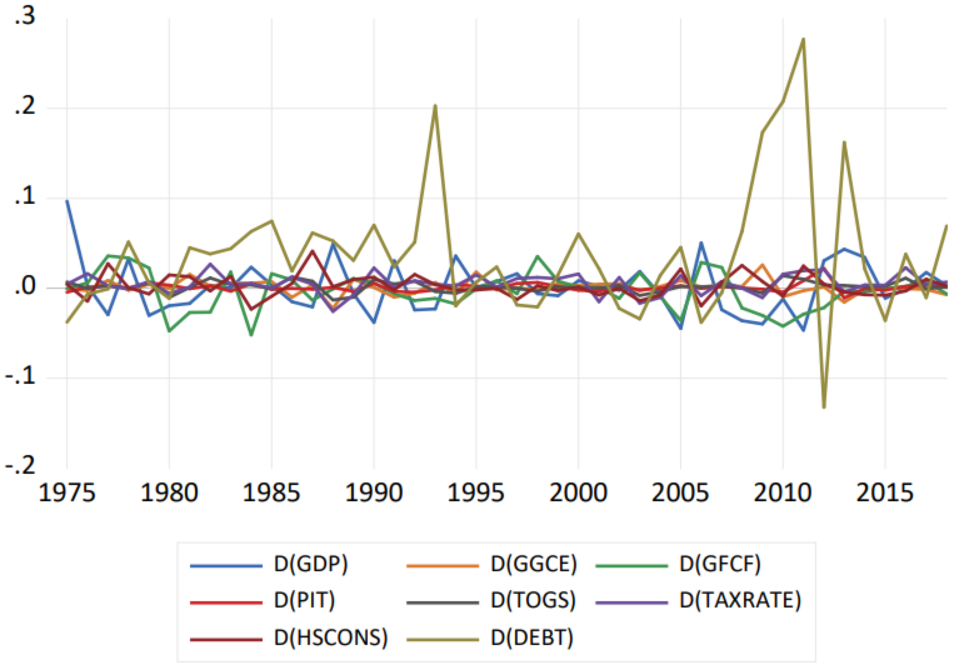
[8] In a presence of cointegration instead of using VAR in levels, we estimate Vector Error Correction Models that combines levels and differences. Therefore, to determine if there exists a long run relationship between dependent and independent variables we proceed with Johansen tests. If the series are cointegrated efficiently represented with error correction models which link short run with long run behavior. The cointegrated variables have a moving average (MA) representation of their 1st-difference. Vector Error Correction Mechanism/model (VECM) includes the error terms of the cointegrating relationships as an error correction term.

some non-stationary variables in the data. Except for the above critical preparatory test, we analyzed the adequacy of the estimated VAR in the context of diagnostic tests. The stability of the VAR model exists when all inverse roots of the characteristic polynomial are within the unit circle and the absolute value is less than one. Granger causality tests also tested whether endogenous variables could be treated as exogenous. The lag exclusion test shows whether all lags of endogenous variables are jointly significant and Lag Length Criteria specify the maximum lags to VAR. Furthermore, the results of VAR are confirmed and tested for autocorrelation, normality and heteroskedasticity of the residuals. Once the model is tested, we provide with an impulse response function analysis, we estimate VAR system using Ordinary Least Squares methods, perform Wald test for coefficients and provide with variance decomposition analysis.

	GDP	GGCE	GFCF	PIT	TOGS	PT	TAXRATE	HSCONS	DEBT
Mean	0.014676	0.183769	0.221424	0.038844	0.115598	0.017618	0.285211	0.649794	0.916742
Median	0.020000	0.182600	0.236900	0.035600	0.116100	0.019000	0.284600	0.661569	0.989600
Maximum	0.067000	0.233100	0.354100	0.070700	0.158000	0.031700	0.400000	0.702175	1.864000
Minimum	-0.101500	0.145700	0.107700	0.016700	0.080500	0.006500	0.182500	0.567792	0.179000
Std. Dev.	0.035668	0.022189	0.060017	0.012878	0.019143	0.007837	0.058738	0.037652	0.524810
Skewness	-1.146762	0.194667	-0.488918	0.578778	0.367266	0.208531	0.100126	-0.630202	0.289986
Kurtosis	4.473706	2.279479	2.959064	2.856215	2.911134	2.024324	2.073238	2.155383	2.116325
Jarque-Bera	13.93511	1.257619	1.795949	2.551145	1.026440	2.111033	1.685603	4.316246	2.094843
Probability	0.000942	0.533226	0.407394	0.279271	0.598565	0.348013	0.430503	0.115542	0.350841
Sum	0.660400	8.269600	9.964100	1.748000	5.201900	0.792800	12.83450	29.24075	41.25340
Sum Sq. Dev.	0.055976	0.021664	0.158488	0.007297	0.016125	0.002703	0.151808	0.062377	12.11873
Observations	45	45	45	45	45	45	45	45	45

Table 1: Descriptive Statistics of the research variable (%), Estimations based on EViews





Levels and Difference Presentation of the variables

Variable	Constant t-statistic	Augmented Dickey-Fuller 5% critical value	p-value	Constant & Linear Trend t-statistic	Augmented Dickey-Fuller 5% critical value	p-value
GDP	-3,14	-2,93	*0,03*	-3,71	-3,52	*0,03*
D(GDP)	-7,97	-2,93	*0,00*	-7,83	-3,52	*0,00*
GGCE	-1,68	-2,93	*0,44*	-2,14	-3,52	*0,51*
D(GGCE)	-8,07	-2,93	*0,00*	-8,09	-3,52	*0,00*
GFCF	-0,52	-2,93	*0,88*	-2,07	-3,52	*0,55*
D(GFCF)	-5,26	-2,93	*0,00*	-5,29	-3,52	*0,00*
PIT	-0,85	-2,93	*0,79*	-3,00	-3,52	*0,14*
D(PIT)	-7,31	-2,93	*0,00*	-7,22	-3,52	*0,00*
TOGS	-0,67	-2,93	*0,84*	-1,89	-3,52	*0,65*
D(TOGS)	-5,98	-2,93	*0,00*	-5,97	-3,52	*0,00*
PT	-0,55	-2,93	*0,83*	-2,02	-3,52	*0,57*
D(PT)	-6,10	-2,93	*0,00*	-6,29	-3,52	*0,00*
TAXRATE	-0,31	-2,93	*0,91*	-2,58	-3,52	*0,29*
D(TAXRATE)	-6,87	-2,93	*0,00*	-6,80	-3,52	*0,00*
HSCONS	-1,72	-2,93	*0,42*	-2,21	-3,52	*0,47*
D(HSCONS)	-7,16	-2,93	*0,00*	-7,14	-3,52	*0,00*
DEBT	0,39	-2,93	*0,98*	-2,04	-3,52	*0,56*

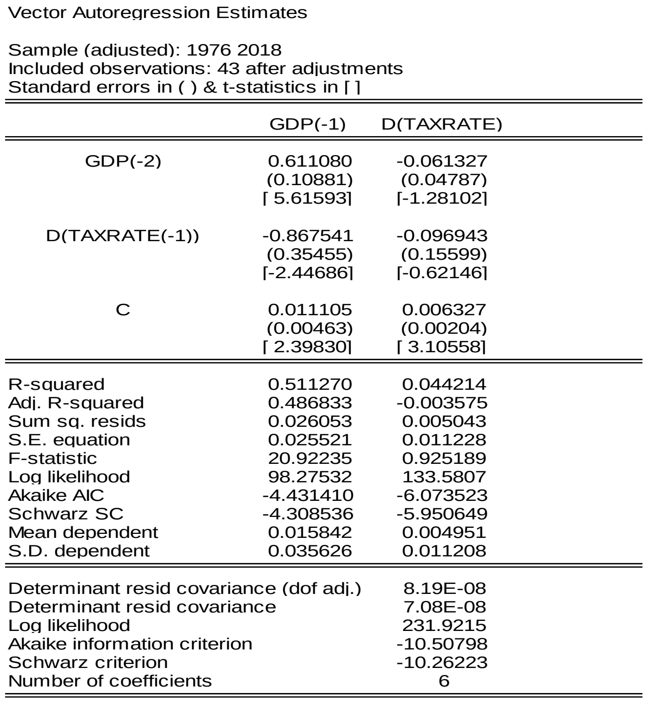
Variable	Constant t-statistic	Augmented Dickey-Fuller 5% critical value	p-value	Constant & Linear Trend t-statistic	Augmented Dickey-Fuller 5% critical value	p-value
D(DEBT)	-6,05	-2,93	*0,00*	-6,04	-3,52	*0,00*

Table 2: Augmented Dickey Fuller Test Authors estimations based on EViews

3. Total Tax Revenue and GDP growth

In this part, we provide the VAR (1,1) estimate and the exact representation between total tax revenue and GDP growth. The estimation result shows that the tax rate negatively affects GDP growth[9] in the short run. The regression shows that a one percent increase in the tax rate lowers the level of GDP growth by 0,86%. In addition, the tax rate and GDP in the previous period can have a strongly positive effect on the figures in the following year.

Model Estimation



```
Vector Autoregression Estimates

Sample (adjusted): 1976 2018
Included observations: 43 after adjustments
Standard errors in ( ) & t-statistics in [ ]
==================================================
                      GDP(-1)     D(TAXRATE)
==================================================
      GDP(-2)         0.611080    -0.061327
                     (0.10881)    (0.04787)
                     [ 5.61593]   [-1.28102]

   D(TAXRATE(-1))    -0.867541    -0.096943
                     (0.35455)    (0.15599)
                     [-2.44686]   [-0.62146]

         C            0.011105     0.006327
                     (0.00463)    (0.00204)
                     [ 2.39830]   [ 3.10558]
==================================================
R-squared             0.511270     0.044214
Adj. R-squared        0.486833    -0.003575
Sum sq. resids        0.026053     0.005043
S.E. equation         0.025521     0.011228
F-statistic           20.92235     0.925189
Log likelihood        98.27532     133.5807
Akaike AIC           -4.431410    -6.073523
Schwarz SC           -4.308536    -5.950649
Mean dependent        0.015842     0.004951
S.D. dependent        0.035626     0.011208
==================================================
Determinant resid covariance (dof adj.)  8.19E-08
Determinant resid covariance             7.08E-08
Log likelihood                           231.9215
Akaike information criterion            -10.50798
Schwarz criterion                       -10.26223
Number of coefficients                       6
==================================================
```

Table 4: Estimation Output and Representation

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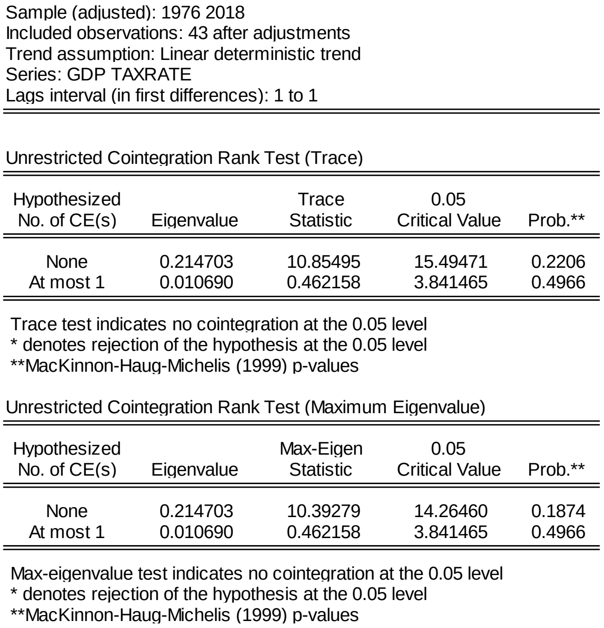
[9] T-statistic -2,44<-1,96 reveals statistical significance between tax rate and GDP growth

Cointegration Analysis

Although the results from VAR provide information on the short-run relationship between macroeconomic variables-in our case, it is crucial to know their long-run behavior[10]. From the table below we test for cointegration we can conclude that VAR model is useful both in short and long run as both trace and max-eigenvalue indicate no cointegration at 5% level. Thus, we do not need to follow error correction methods.



```
Sample (adjusted): 1976 2018
Included observations: 43 after adjustments
Trend assumption: Linear deterministic trend
Series: GDP TAXRATE
Lags interval (in first differences): 1 to 1
==========================================================

Unrestricted Cointegration Rank Test (Trace)
==========================================================
 Hypothesized                  Trace        0.05
  No. of CE(s)   Eigenvalue   Statistic   Critical Value   Prob.**
==========================================================
     None        0.214703     10.85495     15.49471      0.2206
   At most 1     0.010690     0.462158     3.841465      0.4966
==========================================================
 Trace test indicates no cointegration at the 0.05 level
 * denotes rejection of the hypothesis at the 0.05 level
 **MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)
==========================================================
 Hypothesized                 Max-Eigen     0.05
  No. of CE(s)   Eigenvalue   Statistic   Critical Value   Prob.**
==========================================================
     None        0.214703     10.39279     14.26460      0.1874
   At most 1     0.010690     0.462158     3.841465      0.4966
==========================================================
 Max-eigenvalue test indicates no cointegration at the 0.05 level
 * denotes rejection of the hypothesis at the 0.05 level
 **MacKinnon-Haug-Michelis (1999) p-values
```

Table 5: Cointegration Analysis

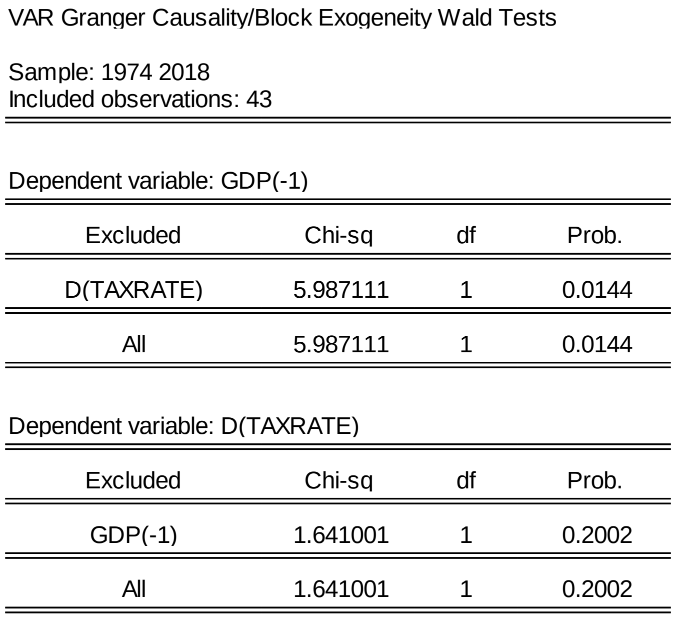
Granger Causality Analysis

In addition, we conducted a Granger causality[11] test to examine the causal relationship between GDP growth and tax rates. As part of the VAR Granger causality/block exogeneity Wald test, we perform the test which results of which are shown in Table 6. The null hypothesis is that excluded variable does no Granger cause equation variable. The probability (p-value=0.2002 > 0.05) suggests that GDP growth has no causal effect on tax rate. However, the probability (p-value=0.0144 < 0.05) suggests that tax rate has Granger causality with GDP growth.

---

[10] Long run behavior can be explained by the VECM not only provides an answer to the question of whether the short-run relationship of the variables is consistent, but also allows for forecasting. Estimating the VECM first requires testing for the presence of cointegration. The unrestricted VAR method explains short-run causality because the time series are cointegrated. VECM is a restricted model in differences.

[11] The Granger causality tests examine the pairwise causal relationship between variables that can cause a one-way interaction, two-way interaction, or no interaction.



VAR Granger Causality/Block Exogeneity Wald Tests

Sample: 1974 2018
Included observations: 43

Dependent variable: GDP(-1)

Excluded	Chi-sq	df	Prob.
D(TAXRATE)	5.987111	1	0.0144
All	5.987111	1	0.0144

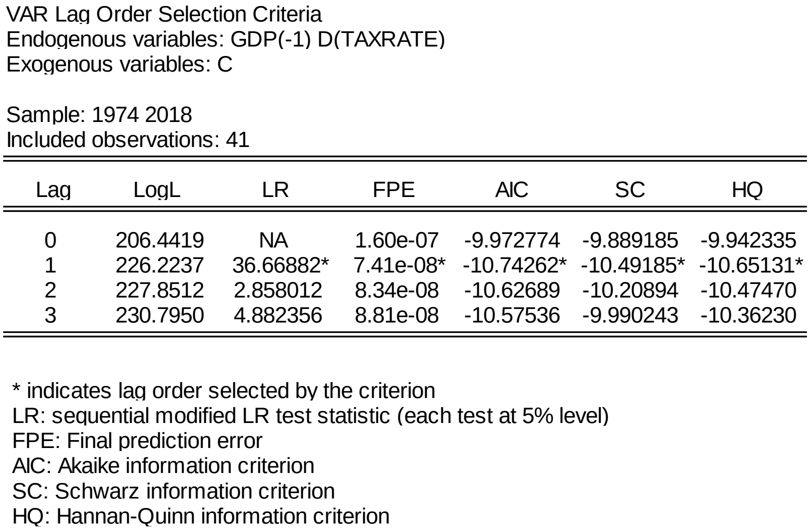
Dependent variable: D(TAXRATE)

Excluded	Chi-sq	df	Prob.
GDP(-1)	1.641001	1	0.2002
All	1.641001	1	0.2002

Table 6: VAR Granger causality/block exogeneity Wald test

Diagnostics Tests of the Model

An important preparatory step in the analysis of impulse response is the VAR Lag Order Selection Criteria. Based on VAR selection from the below table we estimate VAR model with 1 lag.



VAR Lag Order Selection Criteria
Endogenous variables: GDP(-1) D(TAXRATE)
Exogenous variables: C

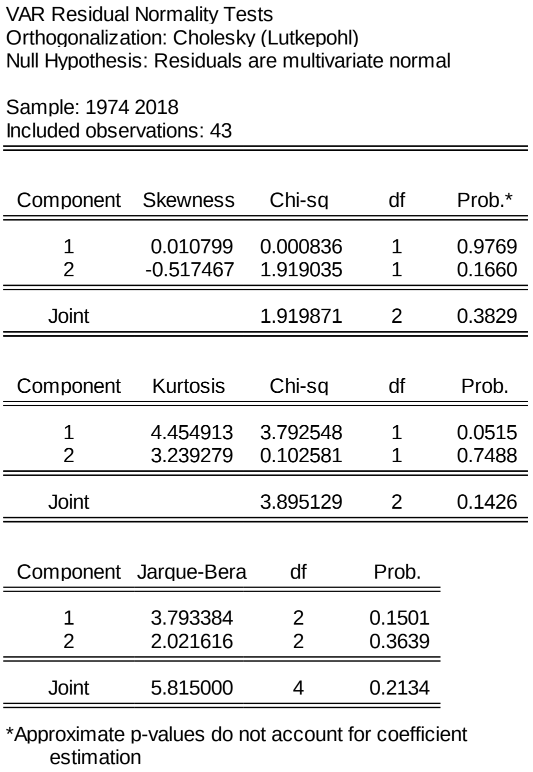
Sample: 1974 2018
Included observations: 41

Lag	LogL	LR	FPE	AIC	SC	HQ
0	206.4419	NA	1.60e-07	-9.972774	-9.889185	-9.942335
1	226.2237	36.66882*	7.41e-08*	-10.74262*	-10.49185*	-10.65131*
2	227.8512	2.858012	8.34e-08	-10.62689	-10.20894	-10.47470
3	230.7950	4.882356	8.81e-08	-10.57536	-9.990243	-10.36230

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

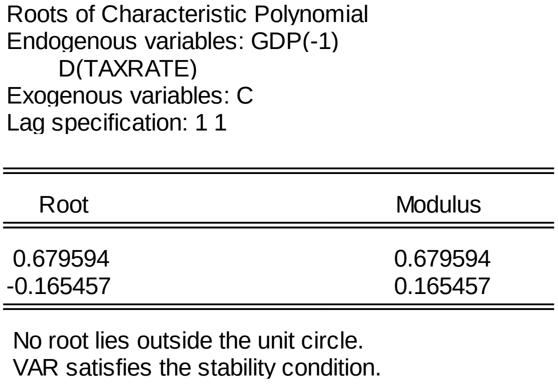
Table 7: VAR Lag Order Selection Criteria

After estimating a VAR model, further analysis is performed focusing on diagnostic tests such as autocorrelation, heteroskedasticity, and non-normality. Thus, we performed the normality test on the residuals and found that the p-value is greater than the 5% significance level. The calculated values for the a p-value for Skewness (0,3829), and Kurtosis (0,1426) and Jarque-Bera (0,2134) are greater than 5% and therefore residuals are multivariate normal. Moreover, an important aspect of VAR process is its stability. This means that it generates stationary time series with time invariant means, variances and covariances structure. Technically, the stability of a VAR system is evaluated by the roots of the characteristic polynomial. More specifically, if the moduli of the eigenvalues of the coefficient matrix are less than one, the VAR process is stable[12] and VAR model variables are stationary. Thus, the stability of a VAR model is indicated by roots that are all less than 1, as shown in the inverse roots of the AR Characteristic Polynomial.



```
VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal

Sample: 1974 2018
Included observations: 43
==========================================================

 Component   Skewness     Chi-sq       df      Prob.*
==========================================================

     1       0.010799    0.000836      1      0.9769
     2      -0.517467    1.919035      1      0.1660
==========================================================

   Joint                 1.919871      2      0.3829
==========================================================

 Component   Kurtosis     Chi-sq       df      Prob.
==========================================================

     1       4.454913    3.792548      1      0.0515
     2       3.239279    0.102581      1      0.7488
==========================================================

   Joint                 3.895129      2      0.1426
==========================================================

 Component  Jarque-Bera    df       Prob.
=========================================

     1       3.793384      2       0.1501
     2       2.021616      2       0.3639
=========================================

   Joint     5.815000      4       0.2134
=========================================

*Approximate p-values do not account for coefficient
    estimation
```

Table 8: VAR Residual Normality Tests

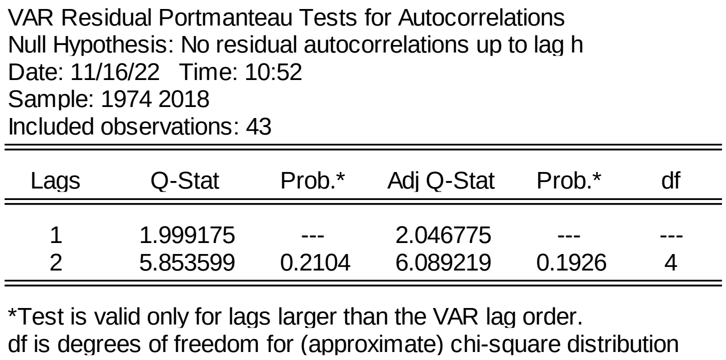


```
Roots of Characteristic Polynomial
Endogenous variables: GDP(-1)
      D(TAXRATE)
Exogenous variables: C
Lag specification: 1 1

================================================

    Root                         Modulus
================================================

 0.679594                        0.679594
-0.165457                        0.165457
================================================

 No root lies outside the unit circle.
 VAR satisfies the stability condition.
```

Table 9: Roots of characteristic polynomial

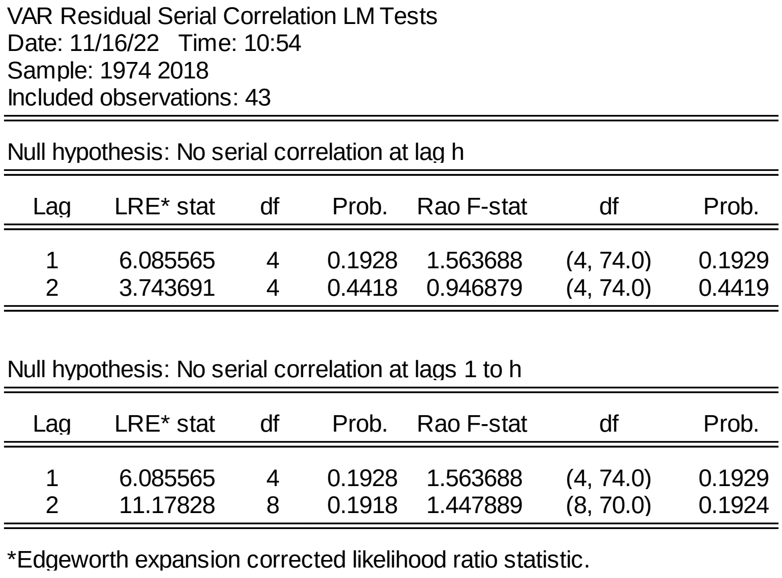
---

[12] If the model is not stable then the estimated results are not valid which can lead to spurious regression. Spurious regression problem arises on trending (instead to economic reasons) or non-stationarity. Possible implications large t and R^2



```
VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 11/16/22   Time: 10:52
Sample: 1974 2018
Included observations: 43
================================================================
   Lags      Q-Stat     Prob.*   Adj Q-Stat    Prob.*      df
================================================================

    1       1.999175     ---      2.046775      ---       ---
    2       5.853599   0.2104     6.089219    0.1926       4
================================================================

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution
```

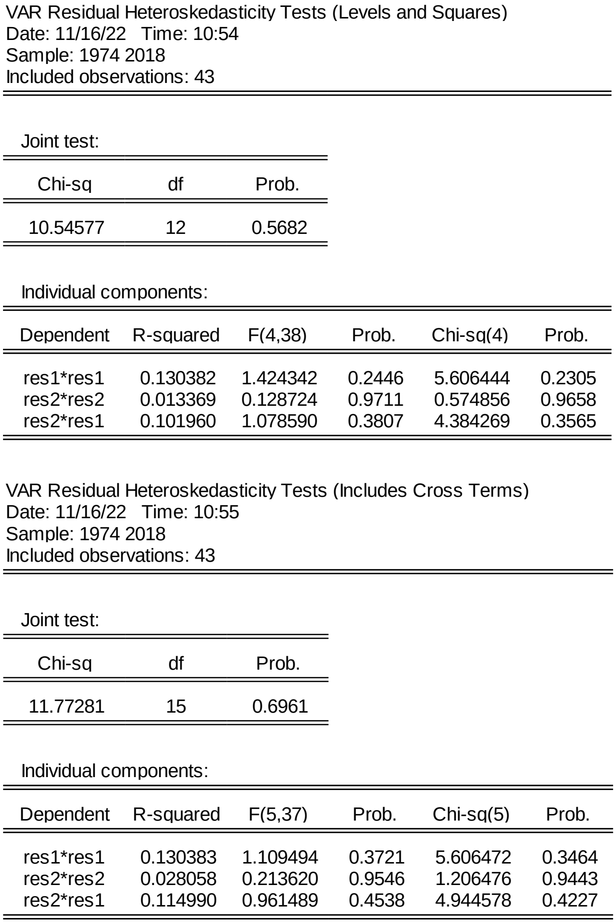
Table 10: VAR Residual Portmanteau Test for Autocorrelations



```
VAR Residual Serial Correlation LM Tests
Date: 11/16/22   Time: 10:54
Sample: 1974 2018
Included observations: 43
======================================================================
Null hypothesis: No serial correlation at lag h
======================================================================
  Lag    LRE* stat    df    Prob.   Rao F-stat      df        Prob.
======================================================================

   1     6.085565     4    0.1928    1.563688   (4, 74.0)    0.1929
   2     3.743691     4    0.4418    0.946879   (4, 74.0)    0.4419
======================================================================

Null hypothesis: No serial correlation at lags 1 to h
======================================================================
  Lag    LRE* stat    df    Prob.   Rao F-stat      df        Prob.
======================================================================

   1     6.085565     4    0.1928    1.563688   (4, 74.0)    0.1929
   2     11.17828     8    0.1918    1.447889   (8, 70.0)    0.1924
======================================================================

*Edgeworth expansion corrected likelihood ratio statistic.
```

Table 11: VAR Residual Serial LM Tests

It is important to confirm the results of VAR after estimating the autocorrelation of the residuals. To achieve this, we test the autocorrelation of the residuals using VAR Residual Serial Correlation LM and Portmanteau Test. The null hypothesis of Portmanteau test as well as Serial Correlation LM test is that there is no autocorrelation between residuals. The test results indicate that there is no serial correlation at lags h and at lags 1 to h, as the calculated p-values are greater than 5%. To use the VAR model, we also need to confirm that there is no heteroskedasticity of the residuals. We use the VAR Residual Heteroscedasticity Test, and the test results are shown in the following table. The p-value is greater than 5%, which means that we confirm that the residuals are heteroskedastic.

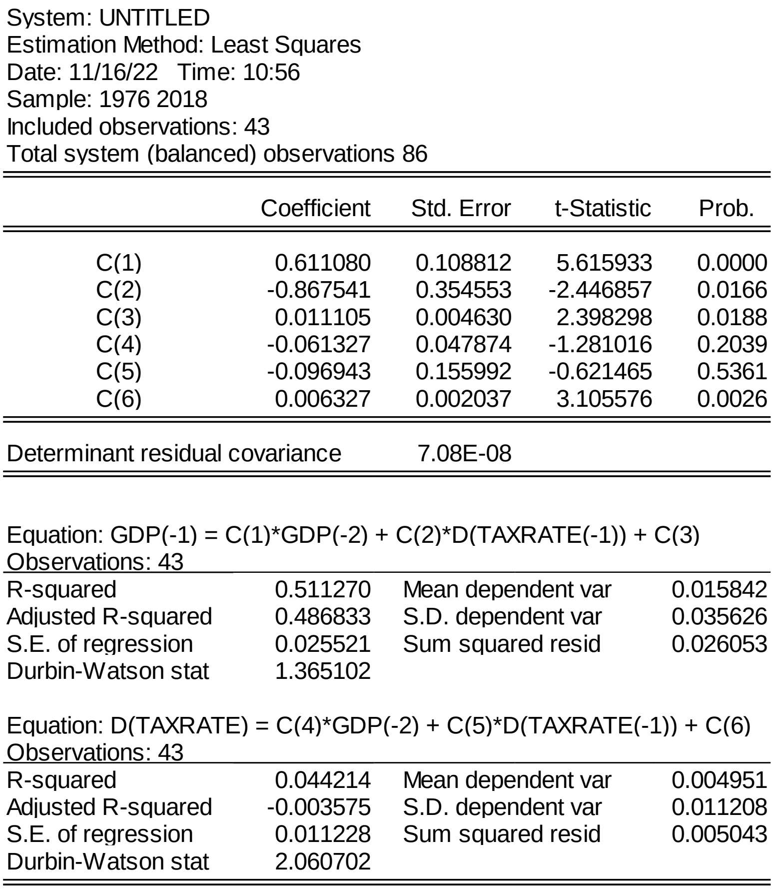


```
VAR Residual Heteroskedasticity Tests (Levels and Squares)
Date: 11/16/22   Time: 10:54
Sample: 1974 2018
Included observations: 43
=====================================================================

 Joint test:
==========================================
  Chi-sq          df          Prob.
==========================================
  10.54577        12          0.5682
==========================================

 Individual components:
=====================================================================
 Dependent   R-squared   F(4,38)     Prob.    Chi-sq(4)    Prob.
=====================================================================
  res1*res1   0.130382   1.424342   0.2446    5.606444    0.2305
  res2*res2   0.013369   0.128724   0.9711    0.574856    0.9658
  res2*res1   0.101960   1.078590   0.3807    4.384269    0.3565
=====================================================================

VAR Residual Heteroskedasticity Tests (Includes Cross Terms)
Date: 11/16/22   Time: 10:55
Sample: 1974 2018
Included observations: 43
=====================================================================

 Joint test:
==========================================
  Chi-sq          df          Prob.
==========================================
  11.77281        15          0.6961
==========================================

 Individual components:
=====================================================================
 Dependent   R-squared   F(5,37)     Prob.    Chi-sq(5)    Prob.
=====================================================================
  res1*res1   0.130383   1.109494   0.3721    5.606472    0.3464
  res2*res2   0.028058   0.213620   0.9546    1.206476    0.9443
  res2*res1   0.114990   0.961489   0.4538    4.944578    0.4227
=====================================================================
```

Table 12: VAR Residual Heteroskedasticity Tests

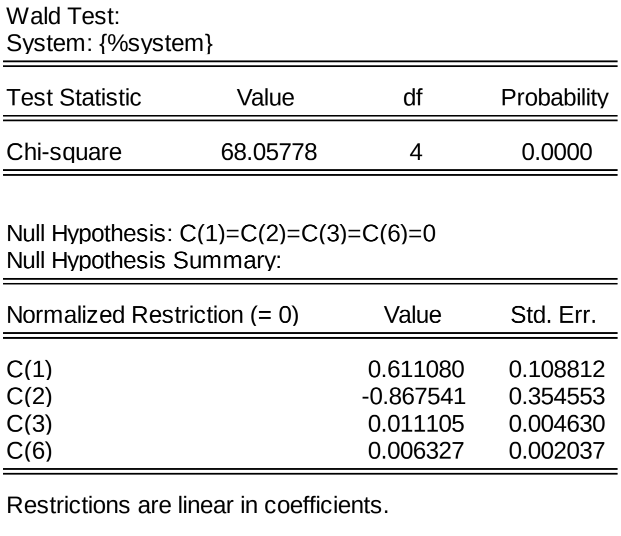
System Estimation Results

From the below table we can see that system shows model with six coefficients, from whom first three are for defining the model of GDP as dependent variable and another three are for defining tax rate. Therefore, based on Wald test, VAR model results confirms that coefficient for the lag of TAXRATE are statistically significant for the lag GDP growth; coefficient for the lag of GDP growth are statistically significant for the current GDP growth. Moreover, we confirm the null hypothesis that tax rate and lagged GDP growth is Grange causal in with GDP. Also, we performed Portmanteau and Normality residual test as well as we present system cross correlations.



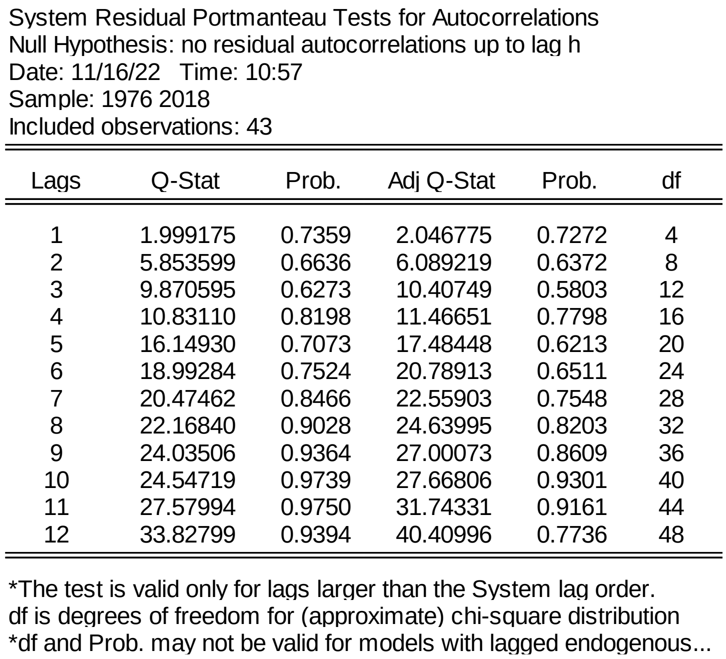
```
System: UNTITLED
Estimation Method: Least Squares
Date: 11/16/22   Time: 10:56
Sample: 1976 2018
Included observations: 43
Total system (balanced) observations 86
==============================================================
                  Coefficient    Std. Error   t-Statistic   Prob.
==============================================================

C(1)               0.611080     0.108812     5.615933     0.0000
C(2)              -0.867541     0.354553    -2.446857     0.0166
C(3)               0.011105     0.004630     2.398298     0.0188
C(4)              -0.061327     0.047874    -1.281016     0.2039
C(5)              -0.096943     0.155992    -0.621465     0.5361
C(6)               0.006327     0.002037     3.105576     0.0026
==============================================================
Determinant residual covariance        7.08E-08
==============================================================


Equation: GDP(-1) = C(1)*GDP(-2) + C(2)*D(TAXRATE(-1)) + C(3)
Observations: 43
--------------------------------------------------------------
R-squared              0.511270    Mean dependent var    0.015842
Adjusted R-squared     0.486833    S.D. dependent var    0.035626
S.E. of regression     0.025521    Sum squared resid     0.026053
Durbin-Watson stat     1.365102

Equation: D(TAXRATE) = C(4)*GDP(-2) + C(5)*D(TAXRATE(-1)) + C(6)
Observations: 43
--------------------------------------------------------------
R-squared              0.044214    Mean dependent var    0.004951
Adjusted R-squared    -0.003575    S.D. dependent var    0.011208
S.E. of regression     0.011228    Sum squared resid     0.005043
Durbin-Watson stat     2.060702
==============================================================
```

Table 13: System Estimation Using Least Squares



```
Wald Test:
System: {%system}
================================================
Test Statistic       Value        df     Probability
================================================

Chi-square          68.05778       4       0.0000
================================================


Null Hypothesis: C(1)=C(2)=C(3)=C(6)=0
Null Hypothesis Summary:
================================================
Normalized Restriction (= 0)       Value       Std. Err.
================================================

C(1)                             0.611080     0.108812
C(2)                            -0.867541     0.354553
C(3)                             0.011105     0.004630
C(6)                             0.006327     0.002037
================================================

Restrictions are linear in coefficients.
```

Table 14: Wald Test of coefficients

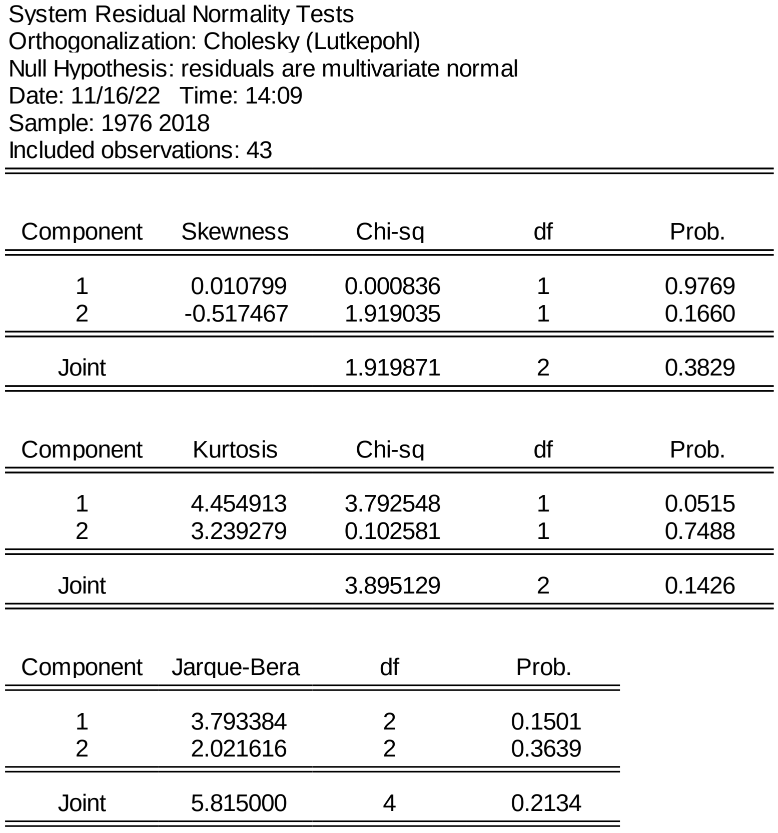


System Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 11/16/22 Time: 10:57
Sample: 1976 2018
Included observations: 43

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	1.999175	0.7359	2.046775	0.7272	4
2	5.853599	0.6636	6.089219	0.6372	8
3	9.870595	0.6273	10.40749	0.5803	12
4	10.83110	0.8198	11.46651	0.7798	16
5	16.14930	0.7073	17.48448	0.6213	20
6	18.99284	0.7524	20.78913	0.6511	24
7	20.47462	0.8466	22.55903	0.7548	28
8	22.16840	0.9028	24.63995	0.8203	32
9	24.03506	0.9364	27.00073	0.8609	36
10	24.54719	0.9739	27.66806	0.9301	40
11	27.57994	0.9750	31.74331	0.9161	44
12	33.82799	0.9394	40.40996	0.7736	48

*The test is valid only for lags larger than the System lag order.
df is degrees of freedom for (approximate) chi-square distribution
*df and Prob. may not be valid for models with lagged endogenous...

Table 15: System Residual Portmanteau Test for Autocorrelations



System Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 11/16/22 Time: 14:09
Sample: 1976 2018
Included observations: 43

Component	Skewness	Chi-sq	df	Prob.
1	0.010799	0.000836	1	0.9769
2	-0.517467	1.919035	1	0.1660
Joint		1.919871	2	0.3829

Component	Kurtosis	Chi-sq	df	Prob.
1	4.454913	3.792548	1	0.0515
2	3.239279	0.102581	1	0.7488
Joint		3.895129	2	0.1426

Component	Jarque-Bera	df	Prob.
1	3.793384	2	0.1501
2	2.021616	2	0.3639
Joint	5.815000	4	0.2134

Table 16: System Residual Normality Test

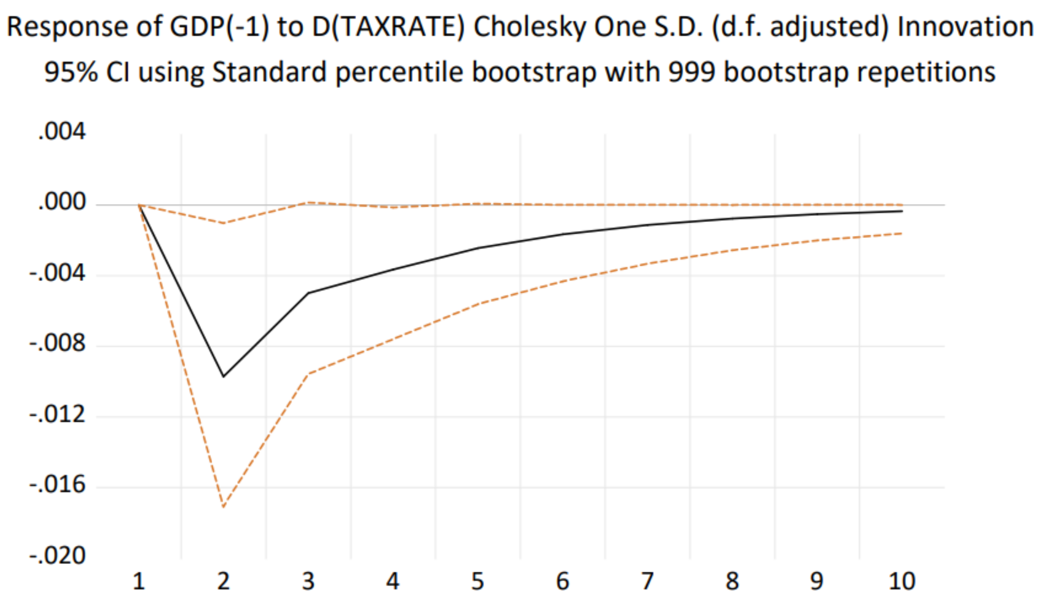
System Residual Cross-Correlations
Ordered by variables
Date: 11/16/22 Time: 14:09
Sample: 1976 2018
Included observations: 43

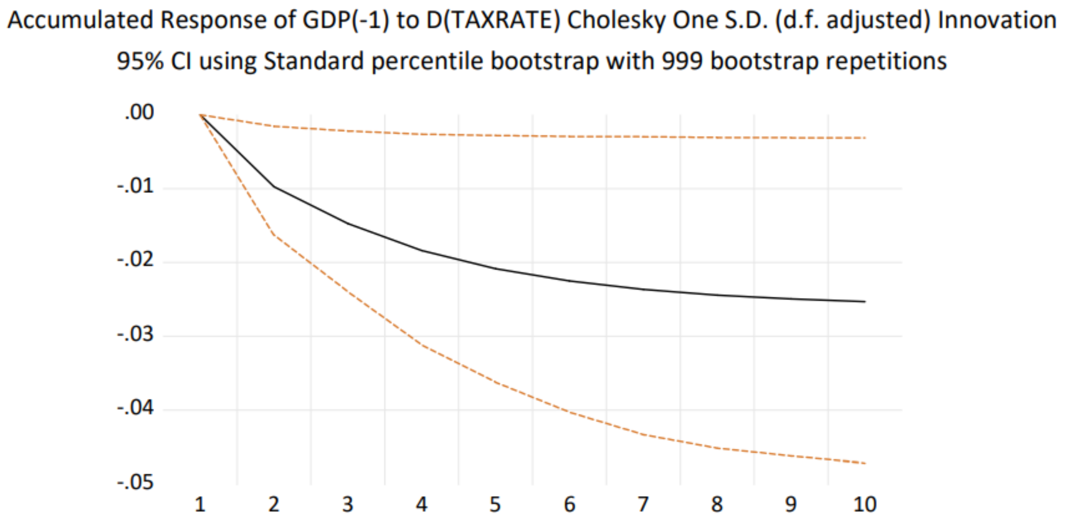
	GDP(-1)	D(TAXRATE)
GDP(-1)	1.000000	-0.055129
GDP(-2)	0.206455	0.037464
GDP(-3)	0.110499	-0.150620
GDP(-4)	0.165495	0.106160
GDP(-5)	0.027340	-0.077615
GDP(-6)	-0.268369	-0.056843
GDP(-7)	0.114683	-0.108151
GDP(-8)	-0.021108	0.129092
GDP(-9)	-0.103526	-0.055869
GDP(-10)	-0.052578	-0.102655
GDP(-11)	-0.033296	0.074922
GDP(-12)	-0.176351	-0.068997
GDP(-13)	-0.056633	-0.279276
D(TAXRATE)	-0.055129	1.000000
D(TAXRATE(-1))	0.006562	-0.036905
D(TAXRATE(-2))	0.122520	-0.197890
D(TAXRATE(-3))	0.218142	-0.048161
D(TAXRATE(-4))	-0.091203	-0.078316
D(TAXRATE(-5))	0.141550	0.169954
D(TAXRATE(-6))	0.134757	-0.151731
D(TAXRATE(-7))	0.073186	-0.122085
D(TAXRATE(-8))	0.144112	0.070423
D(TAXRATE(-9))	0.102714	-0.138980
D(TAXRATE(-10))	-0.071697	-0.004532
D(TAXRATE(-11))	-0.104327	-0.131487
D(TAXRATE(-12))	-0.242103	-0.013214

Asymptotic standard error (lag>0): 0.152499

Table 17: System Residual Cross Correlations

Impulse Responses Functions


Response of GDP(-1) to D(TAXRATE) Cholesky One S.D. (d.f. adjusted) Innovation
95% CI using Standard percentile bootstrap with 999 bootstrap repetitions



Impulse Response Functions GDP growth and TAXRATE

The impulse response analysis is based upon the Wold moving average representation of VAR process and it is used to investigate dynamic interaction between endogenous variables. Therefore, as it can be seen clearly from the above chart, a one standard deviation shock in the tax rate can lead to a substantial decline in GDP growth. This negative response continues to worsen through period 2. The response remains in negative region with an upward trend through period 3. The level of GDP growth remains in steady state through periods 5 to 10. It is critical to say that the above effects are for a one-time-only change, and would fade out to zero in the long run. The effects of a permanent change are given by the cumulative sums of the above IRFs. For example, the effects on future GDP values of a permanent one-unit upward shift in TAX RATE [13].

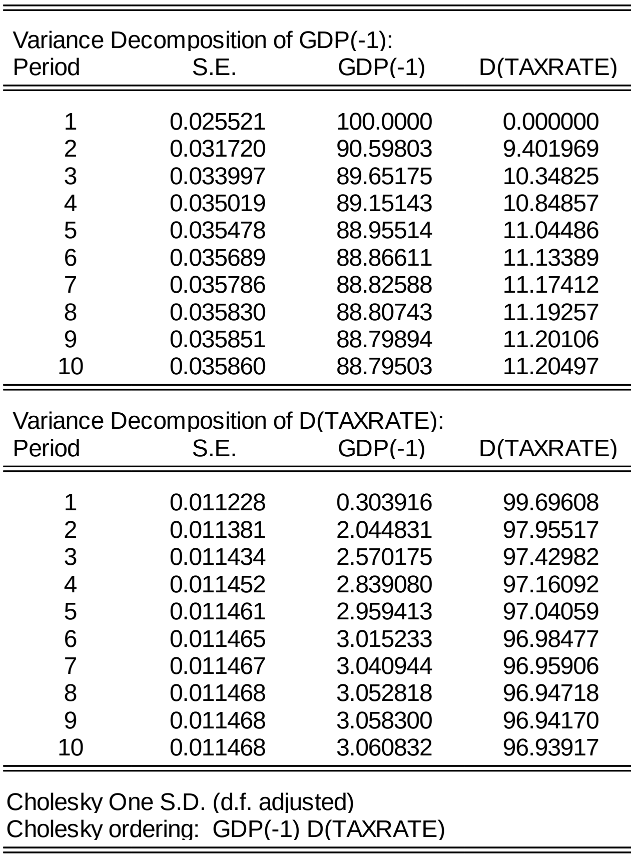
Variance Decomposition Analysis

Using the estimated model, which provides information about the long-term relationship of the variables, we also perform a variance decomposition analysis, which allows us to characterize the dynamic behavior of the model. Table 20 suggests that in the long run, the variation of real GDP growth depends also on shocks to tax rates. More analytically, in the short run, impulse or shock to GDP growth accounts 89,65 percent variation of the fluctuation in GDP growth (own shock). This implies that GDP growth is strongly endogenous. In the short run shocks to tax rates can cause 10,34 percent variation in GDP growth which indicated that taxation policy is strongly exogenous. On the other hand, in the long run impulse or shock to GDP growth accounts 88,79 percent variation of the fluctuation in GDP growth (own shock). This implies that GDP growth is strongly endogenous in the long run while shocks to tax rates can cause 11,20 percent variation in GDP growth which indicated that taxation policy is still strongly exogenous in

---

[13] From accumulated IRF we find -0,025 at horizon t=10.

long run. This model confirms that tax rates and tax policy in the short-run, as a policy-making tool for overall economic growth, have a Granger causality effect on GDP for the period studied from 1974 to 2018, implying that the setting and structure of taxation is important not only for fiscal consolidation issues but also for the impact on economic development.



Variance Decomposition of GDP(-1):

Period	S.E.	GDP(-1)	D(TAXRATE)
1	0.025521	100.0000	0.000000
2	0.031720	90.59803	9.401969
3	0.033997	89.65175	10.34825
4	0.035019	89.15143	10.84857
5	0.035478	88.95514	11.04486
6	0.035689	88.86611	11.13389
7	0.035786	88.82588	11.17412
8	0.035830	88.80743	11.19257
9	0.035851	88.79894	11.20106
10	0.035860	88.79503	11.20497

Variance Decomposition of D(TAXRATE):

Period	S.E.	GDP(-1)	D(TAXRATE)
1	0.011228	0.303916	99.69608
2	0.011381	2.044831	97.95517
3	0.011434	2.570175	97.42982
4	0.011452	2.839080	97.16092
5	0.011461	2.959413	97.04059
6	0.011465	3.015233	96.98477
7	0.011467	3.040944	96.95906
8	0.011468	3.052818	96.94718
9	0.011468	3.058300	96.94170
10	0.011468	3.060832	96.93917

Cholesky One S.D. (d.f. adjusted)
Cholesky ordering: GDP(-1) D(TAXRATE)

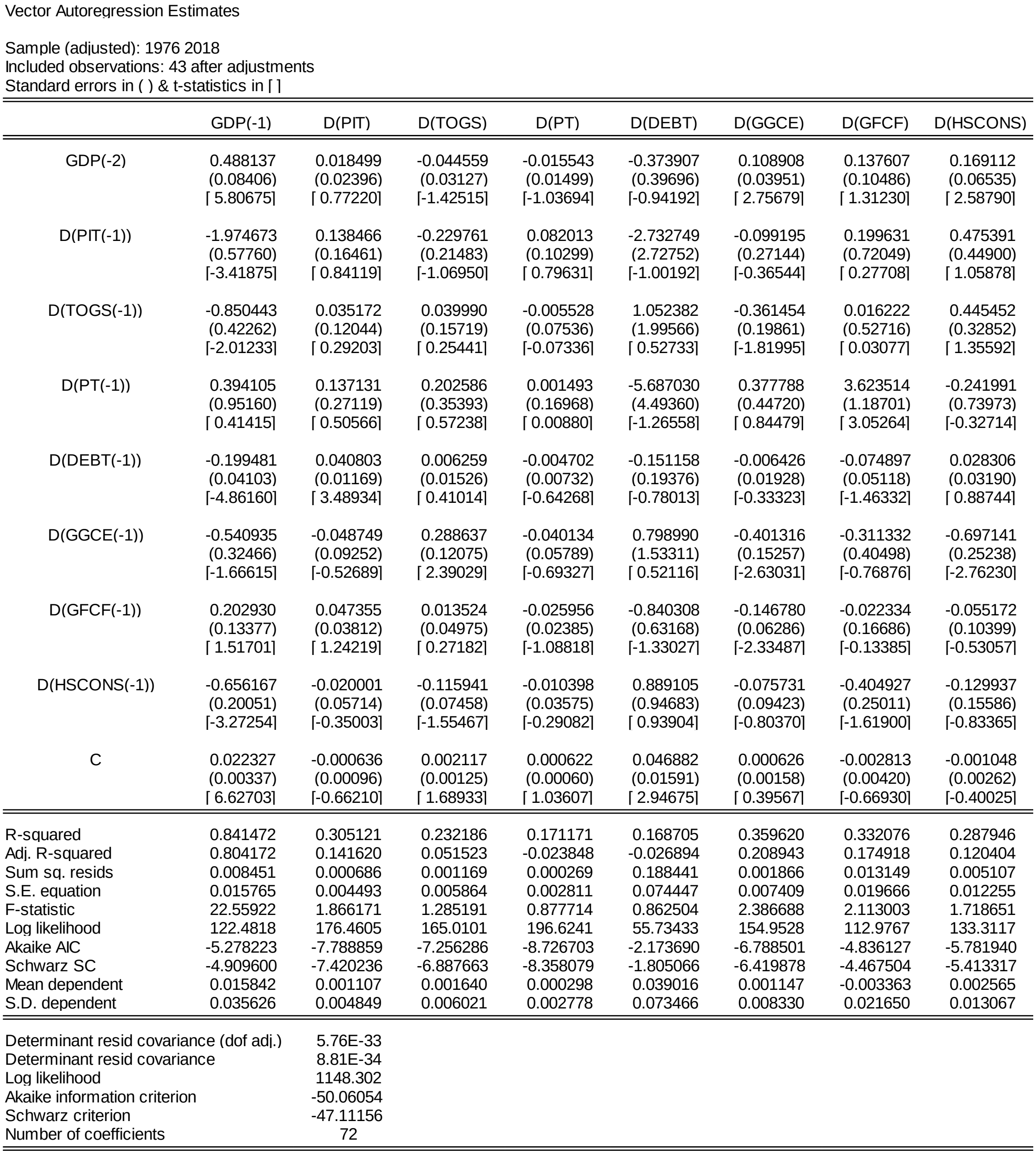
Table 18: Variance Decomposition

4.Decomposition of Tax Revenue, GDP and Other Macroeconomic Variables

In this section we estimate vector autoregressive model (VAR Model2) VAR (1,1) and examine the short-run relationship among real GDP growth, personal income taxes, tax on goods and services, property taxes, debt, general government consumption expenditure, gross fixed capital formation and household consumption. All the endogenous variable are the differenced time series except for lagged growth to avoid non-stationarity issues. Also, it is obvious that our variables are connected with short-run relationship. Our estimation result suggests personal income taxes, tax on goods and services, debt, general government consumption expenditure, and household consumption are negatively [14] correlated with GDP growth while lagged GDP growth is positively correlated with GDP growth of current period. Also, property taxes are positively correlated with gross fixed capital formation, debt is positively correlated with personal income tax and government expenditures with tax on goods and services. Government expenditures is negatively correlated with gross fixed capital formation. The vector autoregression estimates are presented in the below table.

---

[14] t > 2, i.e., statistically significant coefficient at 5% level. Government and household consumption expenditures are also negatively correlated, but not with statistical significance at the 5% level



Vector Autoregression Estimates

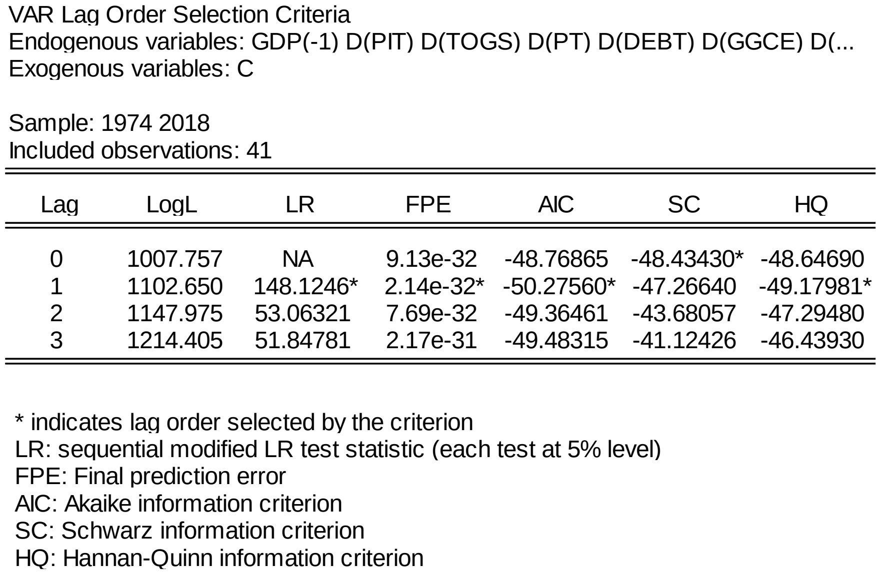
Sample (adjusted): 1976 2018
Included observations: 43 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	GDP(-1)	D(PIT)	D(TOGS)	D(PT)	D(DEBT)	D(GGCE)	D(GFCF)	D(HSCONS)
GDP(-2)	0.488137	0.018499	-0.044559	-0.015543	-0.373907	0.108908	0.137607	0.169112
	(0.08406)	(0.02396)	(0.03127)	(0.01499)	(0.39696)	(0.03951)	(0.10486)	(0.06535)
	[5.80675]	[0.77220]	[-1.42515]	[-1.03694]	[-0.94192]	[2.75679]	[1.31230]	[2.58790]
D(PIT(-1))	-1.974673	0.138466	-0.229761	0.082013	-2.732749	-0.099195	0.199631	0.475391
	(0.57760)	(0.16461)	(0.21483)	(0.10299)	(2.72752)	(0.27144)	(0.72049)	(0.44900)
	[-3.41875]	[0.84119]	[-1.06950]	[0.79631]	[-1.00192]	[-0.36544]	[0.27708]	[1.05878]
D(TOGS(-1))	-0.850443	0.035172	0.039990	-0.005528	1.052382	-0.361454	0.016222	0.445452
	(0.42262)	(0.12044)	(0.15719)	(0.07536)	(1.99566)	(0.19861)	(0.52716)	(0.32852)
	[-2.01233]	[0.29203]	[0.25441]	[-0.07336]	[0.52733]	[-1.81995]	[0.03077]	[1.35592]
D(PT(-1))	0.394105	0.137131	0.202586	0.001493	-5.687030	0.377788	3.623514	-0.241991
	(0.95160)	(0.27119)	(0.35393)	(0.16968)	(4.49360)	(0.44720)	(1.18701)	(0.73973)
	[0.41415]	[0.50566]	[0.57238]	[0.00880]	[-1.26558]	[0.84479]	[3.05264]	[-0.32714]
D(DEBT(-1))	-0.199481	0.040803	0.006259	-0.004702	-0.151158	-0.006426	-0.074897	0.028306
	(0.04103)	(0.01169)	(0.01526)	(0.00732)	(0.19376)	(0.01928)	(0.05118)	(0.03190)
	[-4.86160]	[3.48934]	[0.41014]	[-0.64268]	[-0.78013]	[-0.33323]	[-1.46332]	[0.88744]
D(GGCE(-1))	-0.540935	-0.048749	0.288637	-0.040134	0.798990	-0.401316	-0.311332	-0.697141
	(0.32466)	(0.09252)	(0.12075)	(0.05789)	(1.53311)	(0.15257)	(0.40498)	(0.25238)
	[-1.66615]	[-0.52689]	[2.39029]	[-0.69327]	[0.52116]	[-2.63031]	[-0.76876]	[-2.76230]
D(GFCF(-1))	0.202930	0.047355	0.013524	-0.025956	-0.840308	-0.146780	-0.022334	-0.055172
	(0.13377)	(0.03812)	(0.04975)	(0.02385)	(0.63168)	(0.06286)	(0.16686)	(0.10399)
	[1.51701]	[1.24219]	[0.27182]	[-1.08818]	[-1.33027]	[-2.33487]	[-0.13385]	[-0.53057]
D(HSCONS(-1))	-0.656167	-0.020001	-0.115941	-0.010398	0.889105	-0.075731	-0.404927	-0.129937
	(0.20051)	(0.05714)	(0.07458)	(0.03575)	(0.94683)	(0.09423)	(0.25011)	(0.15586)
	[-3.27254]	[-0.35003]	[-1.55467]	[-0.29082]	[0.93904]	[-0.80370]	[-1.61900]	[-0.83365]
C	0.022327	-0.000636	0.002117	0.000622	0.046882	0.000626	-0.002813	-0.001048
	(0.00337)	(0.00096)	(0.00125)	(0.00060)	(0.01591)	(0.00158)	(0.00420)	(0.00262)
	[6.62703]	[-0.66210]	[1.68933]	[1.03607]	[2.94675]	[0.39567]	[-0.66930]	[-0.40025]
R-squared	0.841472	0.305121	0.232186	0.171171	0.168705	0.359620	0.332076	0.287946
Adj. R-squared	0.804172	0.141620	0.051523	-0.023848	-0.026894	0.208943	0.174918	0.120404
Sum sq. resids	0.008451	0.000686	0.001169	0.000269	0.188441	0.001866	0.013149	0.005107
S.E. equation	0.015765	0.004493	0.005864	0.002811	0.074447	0.007409	0.019666	0.012255
F-statistic	22.55922	1.866171	1.285191	0.877714	0.862504	2.386688	2.113003	1.718651
Log likelihood	122.4818	176.4605	165.0101	196.6241	55.73433	154.9528	112.9767	133.3117
Akaike AIC	-5.278223	-7.788859	-7.256286	-8.726703	-2.173690	-6.788501	-4.836127	-5.781940
Schwarz SC	-4.909600	-7.420236	-6.887663	-8.358079	-1.805066	-6.419878	-4.467504	-5.413317
Mean dependent	0.015842	0.001107	0.001640	0.000298	0.039016	0.001147	-0.003363	0.002565
S.D. dependent	0.035626	0.004849	0.006021	0.002778	0.073466	0.008330	0.021650	0.013067

Determinant resid covariance (dof adj.)	5.76E-33
Determinant resid covariance	8.81E-34
Log likelihood	1148.302
Akaike information criterion	-50.06054
Schwarz criterion	-47.11156
Number of coefficients	72

Table 19: Model 2 Estimation Output and Representation

Diagnostics tests of VAR Model 2



VAR Lag Order Selection Criteria
Endogenous variables: GDP(-1) D(PIT) D(TOGS) D(PT) D(DEBT) D(GGCE) D(...
Exogenous variables: C

Sample: 1974 2018
Included observations: 41

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1007.757	NA	9.13e-32	-48.76865	-48.43430*	-48.64690
1	1102.650	148.1246*	2.14e-32*	-50.27560*	-47.26640	-49.17981*
2	1147.975	53.06321	7.69e-32	-49.36461	-43.68057	-47.29480
3	1214.405	51.84781	2.17e-31	-49.48315	-41.12426	-46.43930

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 20: Model 2 VAR Lag Order Selection Criteria

Based on the above test of VAR Lag Order Selection Criteria, we will first estimate the model VAR with one lag. Moreover, the following table of roots of the characteristic polynomial shows that no root is outside the unit circle and the VAR satisfies the stability condition. Also, there is no autocorrelation, heteroskedasticity between the residuals and normality test is performed.[15]

.

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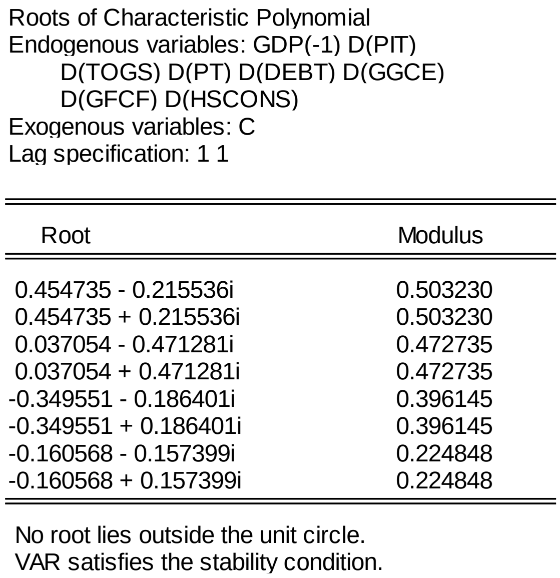
[15] During the analysis of the VAR, we need to estimate coefficients that are BLUE (best linear unbiased estimators). Non normality issues are a due to the fact of small sample but no presence of autocorrelation, heteroscedasticity and stability allow us to interpret statistical significance.



```
Roots of Characteristic Polynomial
Endogenous variables: GDP(-1) D(PIT)
        D(TOGS) D(PT) D(DEBT) D(GGCE)
        D(GFCF) D(HSCONS)
Exogenous variables: C
Lag specification: 1 1

     Root                              Modulus

 0.454735 - 0.215536i                  0.503230
 0.454735 + 0.215536i                  0.503230
 0.037054 - 0.471281i                  0.472735
 0.037054 + 0.471281i                  0.472735
-0.349551 - 0.186401i                  0.396145
-0.349551 + 0.186401i                  0.396145
-0.160568 - 0.157399i                  0.224848
-0.160568 + 0.157399i                  0.224848

 No root lies outside the unit circle.
 VAR satisfies the stability condition.
```

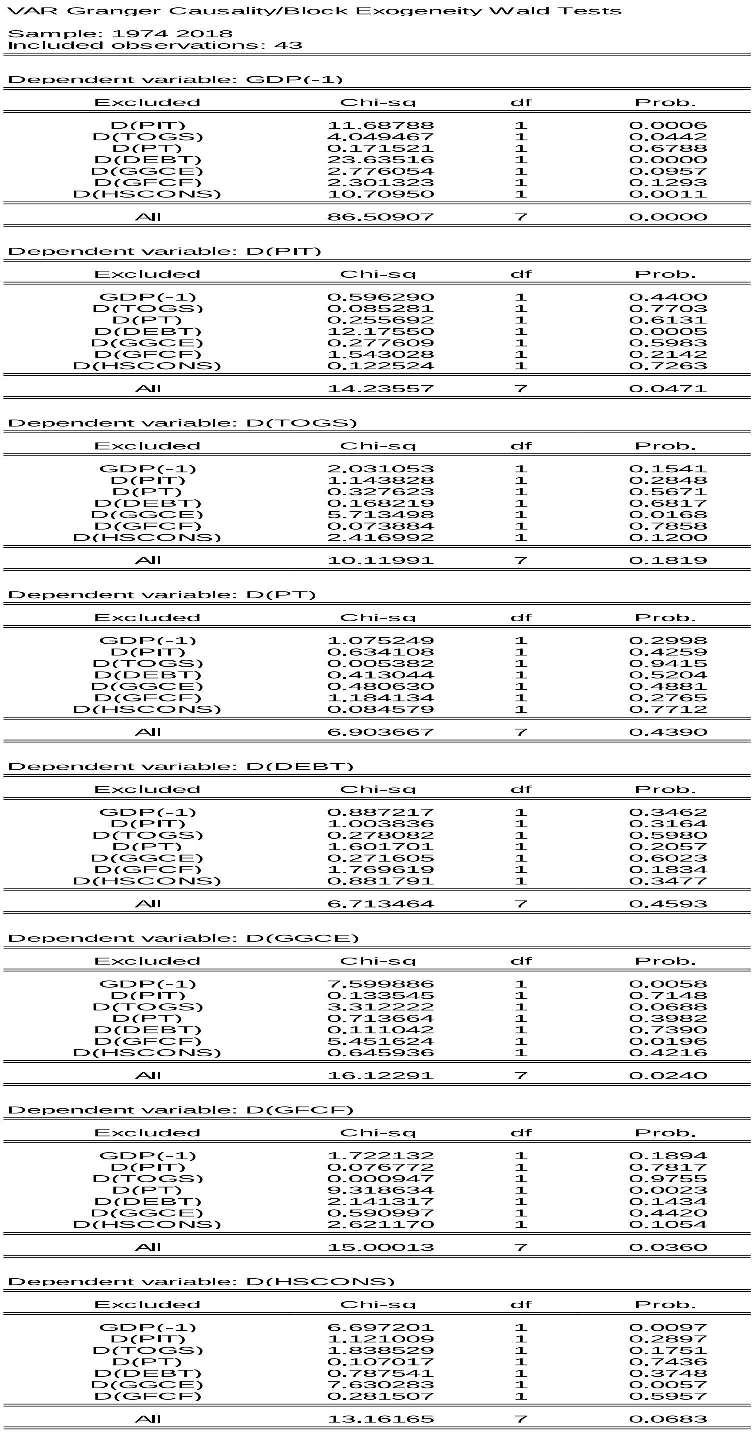
Table 21: VAR Model 2 Roots of characteristic polynomial

Granger Causality Test

In addition, we performed a Granger causality test to examine the causal relationship between the endogenous variables. The results presented in the below table, demonstrate the existence of a short-run relationship between the variables. The null hypothesis states that the excluded variable has no Granger causality with the equation variable[16], and the ALL states that all endogenous variables except those of the dependent variable are jointly zero.

---

[16] $p<5\%$ we reject the null hypothesis



VAR Granger Causality/Block Exogeneity Wald Tests

Sample: 1974 2018
Included observations: 43

Dependent variable: GDP(-1)

Excluded	Chi-sq	df	Prob.
D(PIT)	11.68788	1	0.0006
D(TOGS)	4.049467	1	0.0442
D(PT)	0.171521	1	0.6788
D(DEBT)	23.63516	1	0.0000
D(GGCE)	2.776054	1	0.0957
D(GFCF)	2.301323	1	0.1293
D(HSCONS)	10.70950	1	0.0011
All	86.50907	7	0.0000

Dependent variable: D(PIT)

Excluded	Chi-sq	df	Prob.
GDP(-1)	0.596290	1	0.4400
D(TOGS)	0.085281	1	0.7703
D(PT)	0.255692	1	0.6131
D(DEBT)	12.17550	1	0.0005
D(GGCE)	0.277609	1	0.5983
D(GFCF)	1.543028	1	0.2142
D(HSCONS)	0.122524	1	0.7263
All	14.23557	7	0.0471

Dependent variable: D(TOGS)

Excluded	Chi-sq	df	Prob.
GDP(-1)	2.031053	1	0.1541
D(PIT)	1.143828	1	0.2848
D(PT)	0.327623	1	0.5671
D(DEBT)	0.168219	1	0.6817
D(GGCE)	5.713498	1	0.0168
D(GFCF)	0.073884	1	0.7858
D(HSCONS)	2.416992	1	0.1200
All	10.11991	7	0.1819

Dependent variable: D(PT)

Excluded	Chi-sq	df	Prob.
GDP(-1)	1.075249	1	0.2998
D(PIT)	0.634108	1	0.4259
D(TOGS)	0.005382	1	0.9415
D(DEBT)	0.413044	1	0.5204
D(GGCE)	0.480630	1	0.4881
D(GFCF)	1.184134	1	0.2765
D(HSCONS)	0.084579	1	0.7712
All	6.903667	7	0.4390

Dependent variable: D(DEBT)

Excluded	Chi-sq	df	Prob.
GDP(-1)	0.887217	1	0.3462
D(PIT)	1.003836	1	0.3164
D(TOGS)	0.278082	1	0.5980
D(PT)	1.601701	1	0.2057
D(GGCE)	0.271605	1	0.6023
D(GFCF)	1.769619	1	0.1834
D(HSCONS)	0.881791	1	0.3477
All	6.713464	7	0.4593

Dependent variable: D(GGCE)

Excluded	Chi-sq	df	Prob.
GDP(-1)	7.599886	1	0.0058
D(PIT)	0.133545	1	0.7148
D(TOGS)	3.312222	1	0.0688
D(PT)	0.713664	1	0.3982
D(DEBT)	0.111042	1	0.7390
D(GFCF)	5.451624	1	0.0196
D(HSCONS)	0.645936	1	0.4216
All	16.12291	7	0.0240

Dependent variable: D(GFCF)

Excluded	Chi-sq	df	Prob.
GDP(-1)	1.722132	1	0.1894
D(PIT)	0.076772	1	0.7817
D(TOGS)	0.000947	1	0.9755
D(PT)	9.318634	1	0.0023
D(DEBT)	2.141317	1	0.1434
D(GGCE)	0.590997	1	0.4420
D(HSCONS)	2.621170	1	0.1054
All	15.00013	7	0.0360

Dependent variable: D(HSCONS)

Excluded	Chi-sq	df	Prob.
GDP(-1)	6.697201	1	0.0097
D(PIT)	1.121009	1	0.2897
D(TOGS)	1.838529	1	0.1751
D(PT)	0.107017	1	0.7436
D(DEBT)	0.787541	1	0.3748
D(GGCE)	7.630283	1	0.0057
D(GFCF)	0.281507	1	0.5957
All	13.16165	7	0.0683

Table 22: Model 2 Granger Causality Test

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 11/17/22 Time: 09:33
Sample: 1974 2018
Included observations: 43

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	14.77027	---	15.12194	---	---
2	59.27929	0.6438	61.80213	0.5546	64

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Table 23: Model 2 VAR Residual Portmanteau Test for Autocorrelations

VAR Residual Serial Correlation LM Tests
Date: 11/17/22 Time: 09:33
Sample: 1974 2018
Included observations: 43

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	58.56765	64	0.6682	0.887188	(64, 116.1)	0.6976
2	41.95364	64	0.9850	0.598694	(64, 116.1)	0.9873

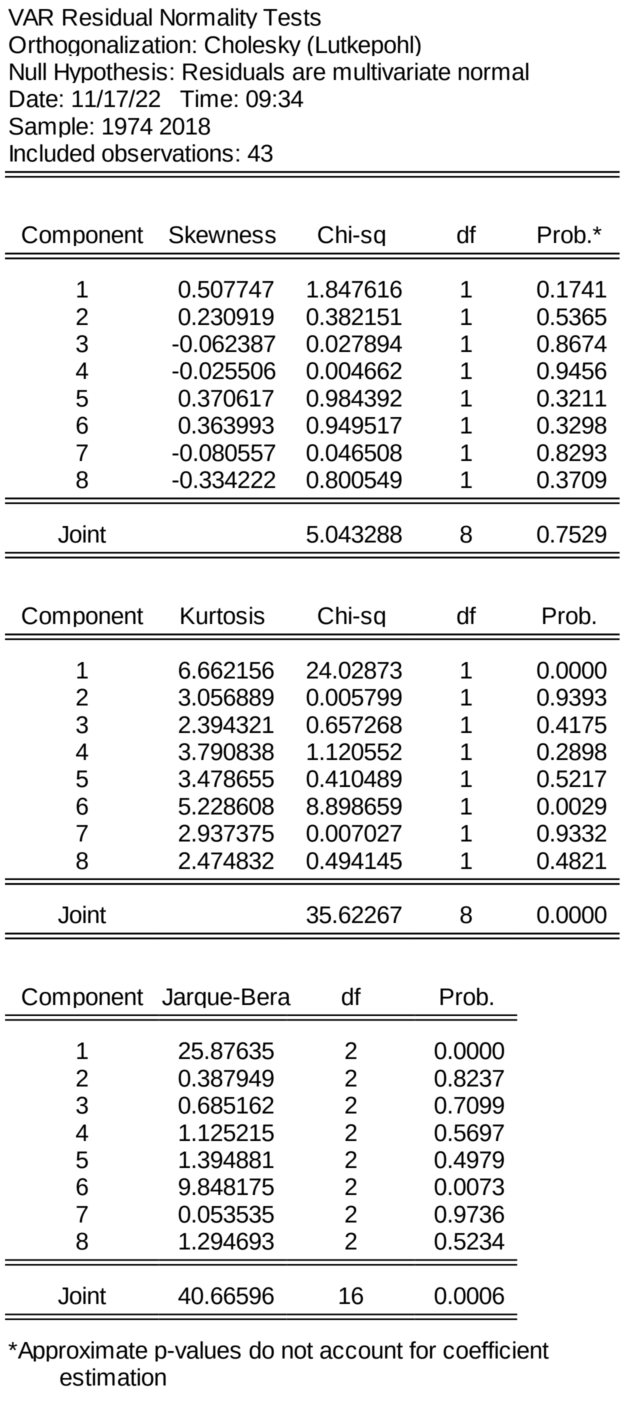
Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	58.56765	64	0.6682	0.887188	(64, 116.1)	0.6976
2	96.69801	128	0.9822	0.622572	(128, 92.0)	0.9934

*Edgeworth expansion corrected likelihood ratio statistic.

Table 24: Model 2 VAR Residual Serial Correlation LM tests

In addition, the results of VAR are tested for the presence of autocorrelation. From the above table, it is clear that in both the Portmanteau test and the serial LM correlation test, the null hypothesis cannot be rejected and we can confirm that there is no autocorrelation between the residuals



```
VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal
Date: 11/17/22   Time: 09:34
Sample: 1974 2018
Included observations: 43
=========================================================

 Component  Skewness      Chi-sq       df      Prob.*
=========================================================

     1       0.507747     1.847616      1      0.1741
     2       0.230919     0.382151      1      0.5365
     3      -0.062387     0.027894      1      0.8674
     4      -0.025506     0.004662      1      0.9456
     5       0.370617     0.984392      1      0.3211
     6       0.363993     0.949517      1      0.3298
     7      -0.080557     0.046508      1      0.8293
     8      -0.334222     0.800549      1      0.3709
=========================================================

   Joint                  5.043288      8      0.7529
=========================================================

 Component  Kurtosis      Chi-sq       df      Prob.
=========================================================

     1       6.662156     24.02873      1      0.0000
     2       3.056889     0.005799      1      0.9393
     3       2.394321     0.657268      1      0.4175
     4       3.790838     1.120552      1      0.2898
     5       3.478655     0.410489      1      0.5217
     6       5.228608     8.898659      1      0.0029
     7       2.937375     0.007027      1      0.9332
     8       2.474832     0.494145      1      0.4821
=========================================================

   Joint                  35.62267      8      0.0000
=========================================================

 Component  Jarque-Bera    df       Prob.
===============================================

     1       25.87635      2       0.0000
     2       0.387949      2       0.8237
     3       0.685162      2       0.7099
     4       1.125215      2       0.5697
     5       1.394881      2       0.4979
     6       9.848175      2       0.0073
     7       0.053535      2       0.9736
     8       1.294693      2       0.5234
===============================================

   Joint     40.66596      16      0.0006
===============================================

*Approximate p-values do not account for coefficient
        estimation
```

Table 25: Model 2 VAR Normality tests

VAR Residual Heteroskedasticity Tests (Levels and Squares)
Date: 11/17/22 Time: 09:34
Sample: 1974 2018
Included observations: 43

Joint test:

Chi-sq	df	Prob.
592.6085	576	0.3070

Individual components:

Dependent	R-squared	F(16,26)	Prob.	Chi-sq(16)	Prob.
res1*res1	0.339308	0.834542	0.6401	14.59024	0.5548
res2*res2	0.662047	3.183358	0.0043	28.46801	0.0278
res3*res3	0.450899	1.334383	0.2494	19.38866	0.2490
res4*res4	0.405664	1.109145	0.3957	17.44356	0.3575
res5*res5	0.600016	2.437663	0.0210	25.80069	0.0569
res6*res6	0.597495	2.412217	0.0222	25.69228	0.0585
res7*res7	0.539839	1.906369	0.0696	23.21306	0.1082
res8*res8	0.315320	0.748372	0.7234	13.55877	0.6315
res2*res1	0.263499	0.581378	0.8698	11.33045	0.7886
res3*res1	0.389246	1.035647	0.4550	16.73759	0.4028
res3*res2	0.345183	0.856609	0.6187	14.84287	0.5362
res4*res1	0.371131	0.959002	0.5223	15.95862	0.4559
res4*res2	0.414253	1.149236	0.3657	17.81288	0.3350
res4*res3	0.272534	0.608780	0.8484	11.71894	0.7631
res5*res1	0.503103	1.645296	0.1257	21.63343	0.1554
res5*res2	0.583632	2.277802	0.0300	25.09620	0.0681
res5*res3	0.583751	2.278910	0.0299	25.10128	0.0681
res5*res4	0.522536	1.778395	0.0930	22.46903	0.1287
res6*res1	0.681316	3.474097	0.0024	29.29659	0.0220
res6*res2	0.304795	0.712440	0.7574	13.10618	0.6650
res6*res3	0.374692	0.973719	0.5090	16.11175	0.4452
res6*res4	0.326198	0.786687	0.6865	14.02651	0.5967
res6*res5	0.499347	1.620760	0.1328	21.47191	0.1611
res7*res1	0.295911	0.682947	0.7846	12.72418	0.6928
res7*res2	0.293506	0.675089	0.7917	12.62074	0.7003
res7*res3	0.525966	1.803025	0.0880	22.61655	0.1244
res7*res4	0.304860	0.712658	0.7572	13.10898	0.6648
res7*res5	0.476125	1.476888	0.1830	20.47339	0.1997
res7*res6	0.506266	1.666245	0.1199	21.76944	0.1508
res8*res1	0.285290	0.648650	0.8150	12.26747	0.7254
res8*res2	0.425652	1.204293	0.3273	18.30302	0.3065
res8*res3	0.358771	0.909195	0.5685	15.42714	0.4936
res8*res4	0.366772	0.941216	0.5386	15.77119	0.4690
res8*res5	0.406319	1.112162	0.3934	17.47174	0.3557
res8*res6	0.388943	1.034326	0.4561	16.72454	0.4036
res8*res7	0.421981	1.186327	0.3395	18.14519	0.3155

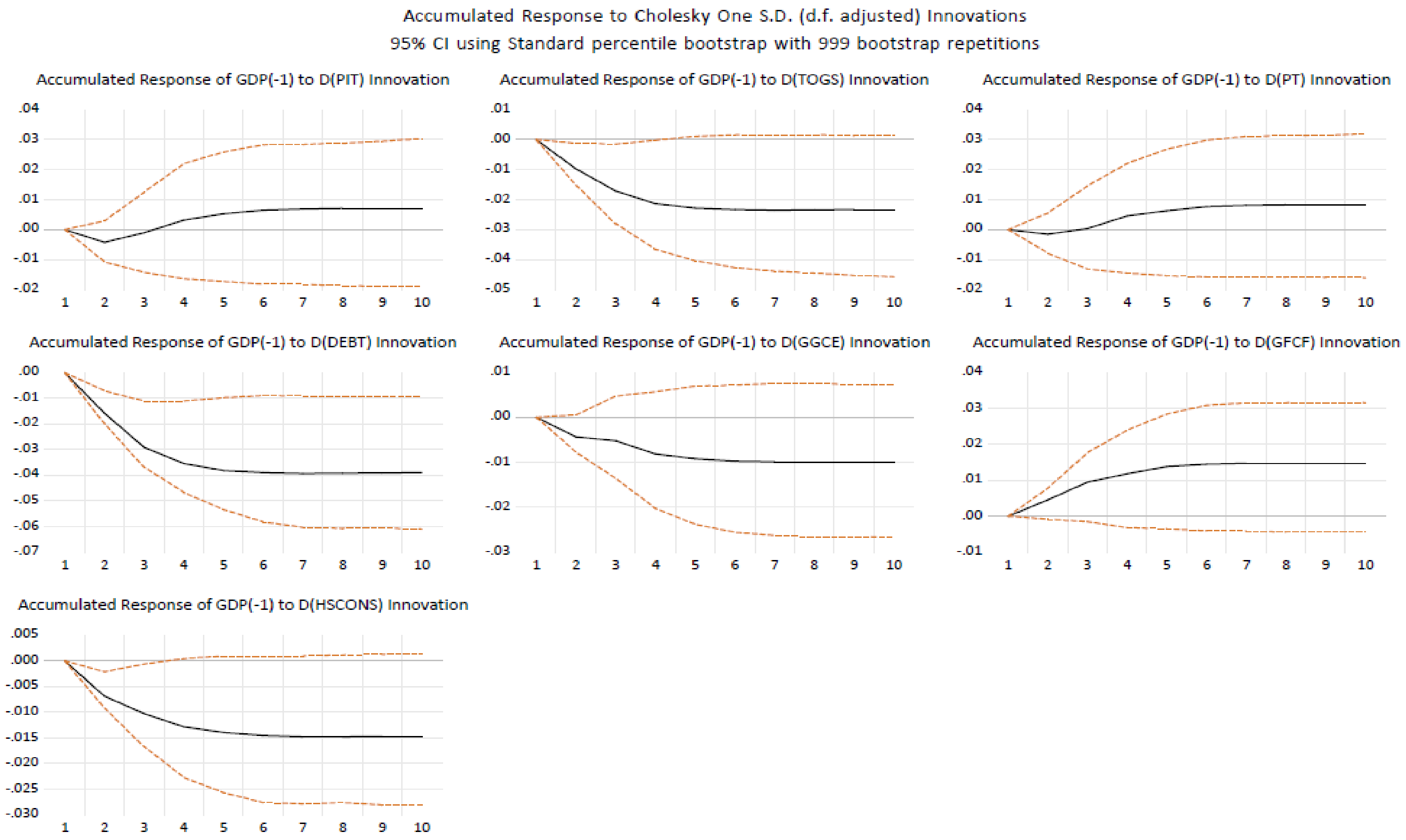
Table 26: Model 2 VAR Residual Heteroscedasticity tests

Another important diagnostic test is the VAR residual heteroscedasticity test. Since the p-value is 0.30 > 0.05, the null hypothesis cannot be rejected, so the residuals can be classified as heteroscedastic.

System Equations Results and Impulse Response Functions

Impulse Responses (Accumulated Responses)

Response to Cholesky One S.D. (d.f. adjusted) Innovations
95% CI using Standard percentile bootstrap with 999 bootstrap repetitions


Accumulated Response to Cholesky One S.D. (d.f. adjusted) Innovations
95% CI using Standard percentile bootstrap with 999 bootstrap repetitions
Accumulated Response of GDP(-1) to D(PIT) Innovation
.04
.03
.02
.01
.00
-.01
-.02
1 2 3 4 5 6 7 8 9 10
Accumulated Response of GDP(-1) to D(TOGS) Innovation
.01
.00
-.01
-.02
-.03
-.04
-.05
1 2 3 4 5 6 7 8 9 10
Accumulated Response of GDP(-1) to D(PT) Innovation
.04
.03
.02
.01
.00
-.01
-.02
1 2 3 4 5 6 7 8 9 10
Accumulated Response of GDP(-1) to D(DEBT) Innovation
.00
-.01
-.02
-.03
-.04
-.05
-.06
-.07
1 2 3 4 5 6 7 8 9 10
Accumulated Response of GDP(-1) to D(GGCE) Innovation
.01
.00
-.01
-.02
-.03
1 2 3 4 5 6 7 8 9 10
Accumulated Response of GDP(-1) to D(GFCF) Innovation
.04
.03
.02
.01
.00
-.01
1 2 3 4 5 6 7 8 9 10
Accumulated Response of GDP(-1) to D(HSCONS) Innovation
.005
.000
-.005
-.010
-.015
-.020
-.025
-.030
1 2 3 4 5 6 7 8 9 10

```
System: UNTITLED
Estimation Method: Least Squares

Sample: 1976 2018
Included observations: 43
Total system (balanced) observations 344
==========================================================================
                      Coefficient     Std. Error     t-Statistic     Prob.
==========================================================================
        C(1)             0.488137       0.084064        5.806750    0.0000
        C(2)            -1.974673       0.577600       -3.418754    0.0007
        C(3)            -0.850443       0.422616       -2.012329    0.0452
        C(4)             0.394105       0.951599        0.414150    0.6791
        C(5)            -0.199481       0.041032       -4.861601    0.0000
        C(6)            -0.540935       0.324662       -1.666149    0.0968
        C(7)             0.202930       0.133770        1.517011    0.1304
        C(8)            -0.656167       0.200507       -3.272538    0.0012
        C(9)             0.022327       0.003369        6.627028    0.0000
        C(10)            0.018499       0.023957        0.772198    0.4407
        C(11)            0.138466       0.164608        0.841191    0.4010
        C(12)            0.035172       0.120439        0.292029    0.7705
        C(13)            0.137131       0.271192        0.505660    0.6135
        C(14)            0.040803       0.011694        3.489341    0.0006
        C(15)           -0.048749       0.092524       -0.526886    0.5987
        C(16)            0.047355       0.038122        1.242187    0.2152
        C(17)           -0.020001       0.057142       -0.350034    0.7266
        C(18)           -0.000636       0.000960       -0.662100    0.5085
        C(19)           -0.044559       0.031266       -1.425150    0.1553
        C(20)           -0.229761       0.214831       -1.069499    0.2858
        C(21)            0.039990       0.157187        0.254412    0.7994
        C(22)            0.202586       0.353935        0.572384    0.5675
        C(23)            0.006259       0.015261        0.410145    0.6820
        C(24)            0.288637       0.120754        2.390292    0.0175
        C(25)            0.013524       0.049754        0.271816    0.7860
        C(26)           -0.115941       0.074576       -1.554668    0.1212
        C(27)            0.002117       0.001253        1.689334    0.0923
        C(28)           -0.015543       0.014989       -1.036942    0.3007
        C(29)            0.082013       0.102991        0.796309    0.4265
        C(30)           -0.005528       0.075356       -0.073361    0.9416
        C(31)            0.001493       0.169678        0.008800    0.9930
        C(32)           -0.004702       0.007316       -0.642685    0.5210
        C(33)           -0.040134       0.057890       -0.693275    0.4887
        C(34)           -0.025956       0.023852       -1.088179    0.2775
        C(35)           -0.010398       0.035752       -0.290824    0.7714
        C(36)            0.000622       0.000601        1.036069    0.3011
        C(37)           -0.373907       0.396962       -0.941922    0.3471
        C(38)           -2.732749       2.727522       -1.001916    0.3173
        C(39)            1.052382       1.995662        0.527335    0.5984
        C(40)           -5.687030       4.493604       -1.265583    0.2067
        C(41)           -0.151158       0.193760       -0.780133    0.4360
        C(42)            0.798990       1.533106        0.521158    0.6027
        C(43)           -0.840308       0.631682       -1.330270    0.1845
        C(44)            0.889105       0.946826        0.939037    0.3485
        C(45)            0.046882       0.015910        2.946749    0.0035
        C(46)            0.108908       0.039505        2.756789    0.0062
        C(47)           -0.099195       0.271441       -0.365438    0.7151
        C(48)           -0.361454       0.198606       -1.819951    0.0699
        C(49)            0.377788       0.447199        0.844786    0.3990
        C(50)           -0.006426       0.019283       -0.333230    0.7392
        C(51)           -0.401316       0.152573       -2.630314    0.0090
        C(52)           -0.146780       0.062864       -2.334871    0.0203
        C(53)           -0.075731       0.094227       -0.803702    0.4223
        C(54)            0.000626       0.001583        0.395672    0.6927
        C(55)            0.137607       0.104860        1.312300    0.1905
        C(56)            0.199631       0.720489        0.277078    0.7819
        C(57)            0.016222       0.527164        0.030772    0.9755
        C(58)            3.623514       1.187008        3.052644    0.0025
        C(59)           -0.074897       0.051183       -1.463324    0.1445
        C(60)           -0.311332       0.404978       -0.768763    0.4427
        C(61)           -0.022334       0.166862       -0.133848    0.8936
        C(62)           -0.404927       0.250109       -1.619003    0.1066
        C(63)           -0.002813       0.004203       -0.669304    0.5039
        C(64)            0.169112       0.065347        2.587895    0.0102
        C(65)            0.475391       0.449000        1.058777    0.2906
        C(66)            0.445452       0.328523        1.355924    0.1762
        C(67)           -0.241991       0.739730       -0.327135    0.7438
        C(68)            0.028306       0.031896        0.887435    0.3756
        C(69)           -0.697141       0.252377       -2.762297    0.0061
        C(70)           -0.055172       0.103986       -0.530572    0.5961
        C(71)           -0.129937       0.155865       -0.833652    0.4052
        C(72)           -0.001048       0.002619       -0.400248    0.6893
==========================================================================
Determinant residual covariance      8.81E-34
==========================================================================
```

```
Equation: GDP(-1) = C(1)*GDP(-2) + C(2)*D(PIT(-1)) + C(3)*D(TOGS(
        -1)) + C(4)*D(PT(-1)) + C(5)*D(DEBT(-1)) + C(6)*D(GGCE(-1)) +
        C(7)*D(GFCF(-1)) + C(8)*D(HSCONS(-1)) + C(9)
Observations: 43
R-squared              0.841472   Mean dependent var      0.015842
Adjusted R-squared     0.804172   S.D. dependent var      0.035626
S.E. of regression     0.015765   Sum squared resid       0.008451
Durbin-Watson stat     1.674293

Equation: D(PIT) = C(10)*GDP(-2) + C(11)*D(PIT(-1)) + C(12)
        *D(TOGS(-1)) + C(13)*D(PT(-1)) + C(14)*D(DEBT(-1)) + C(15)
        *D(GGCE(-1)) + C(16)*D(GFCF(-1)) + C(17)*D(HSCONS(-1)) +
        C(18)
Observations: 43
R-squared              0.305121   Mean dependent var      0.001107
Adjusted R-squared     0.141620   S.D. dependent var      0.004849
S.E. of regression     0.004493   Sum squared resid       0.000686
Durbin-Watson stat     1.969193

Equation: D(TOGS) = C(19)*GDP(-2) + C(20)*D(PIT(-1)) + C(21)
        *D(TOGS(-1)) + C(22)*D(PT(-1)) + C(23)*D(DEBT(-1)) + C(24)
        *D(GGCE(-1)) + C(25)*D(GFCF(-1)) + C(26)*D(HSCONS(-1)) +
        C(27)
Observations: 43
R-squared              0.232186   Mean dependent var      0.001640
Adjusted R-squared     0.051523   S.D. dependent var      0.006021
S.E. of regression     0.005864   Sum squared resid       0.001169
Durbin-Watson stat     2.096284

Equation: D(PT) = C(28)*GDP(-2) + C(29)*D(PIT(-1)) + C(30)*D(TOGS(
        -1)) + C(31)*D(PT(-1)) + C(32)*D(DEBT(-1)) + C(33)*D(GGCE(-1))
        + C(34)*D(GFCF(-1)) + C(35)*D(HSCONS(-1)) + C(36)
Observations: 43
R-squared              0.171171   Mean dependent var      0.000298
Adjusted R-squared    -0.023848   S.D. dependent var      0.002778
S.E. of regression     0.002811   Sum squared resid       0.000269
Durbin-Watson stat     2.085470

Equation: D(DEBT) = C(37)*GDP(-2) + C(38)*D(PIT(-1)) + C(39)
        *D(TOGS(-1)) + C(40)*D(PT(-1)) + C(41)*D(DEBT(-1)) + C(42)
        *D(GGCE(-1)) + C(43)*D(GFCF(-1)) + C(44)*D(HSCONS(-1)) +
        C(45)
Observations: 43
R-squared              0.168705   Mean dependent var      0.039016
Adjusted R-squared    -0.026894   S.D. dependent var      0.073466
S.E. of regression     0.074447   Sum squared resid       0.188441
Durbin-Watson stat     1.934929

Equation: D(GGCE) = C(46)*GDP(-2) + C(47)*D(PIT(-1)) + C(48)
        *D(TOGS(-1)) + C(49)*D(PT(-1)) + C(50)*D(DEBT(-1)) + C(51)
        *D(GGCE(-1)) + C(52)*D(GFCF(-1)) + C(53)*D(HSCONS(-1)) +
        C(54)
Observations: 43
R-squared              0.359620   Mean dependent var      0.001147
Adjusted R-squared     0.208943   S.D. dependent var      0.008330
S.E. of regression     0.007409   Sum squared resid       0.001866
Durbin-Watson stat     1.906459

Equation: D(GFCF) = C(55)*GDP(-2) + C(56)*D(PIT(-1)) + C(57)
        *D(TOGS(-1)) + C(58)*D(PT(-1)) + C(59)*D(DEBT(-1)) + C(60)
        *D(GGCE(-1)) + C(61)*D(GFCF(-1)) + C(62)*D(HSCONS(-1)) +
        C(63)
Observations: 43
R-squared              0.332076   Mean dependent var     -0.003363
Adjusted R-squared     0.174918   S.D. dependent var      0.021650
S.E. of regression     0.019666   Sum squared resid       0.013149
Durbin-Watson stat     2.005402

Equation: D(HSCONS) = C(64)*GDP(-2) + C(65)*D(PIT(-1)) + C(66)
        *D(TOGS(-1)) + C(67)*D(PT(-1)) + C(68)*D(DEBT(-1)) + C(69)
        *D(GGCE(-1)) + C(70)*D(GFCF(-1)) + C(71)*D(HSCONS(-1)) +
        C(72)
Observations: 43
R-squared              0.287946   Mean dependent var      0.002565
Adjusted R-squared     0.120404   S.D. dependent var      0.013067
S.E. of regression     0.012255   Sum squared resid       0.005107
Durbin-Watson stat     2.022876
```

Table 27: Model 2 VAR System Equation

System Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 11/17/22 Time: 10:06
Sample: 1976 2018
Included observations: 43

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	14.77027	1.0000	15.12194	1.0000	64
2	59.27929	1.0000	61.80213	1.0000	128
3	126.6685	0.9999	134.2455	0.9995	192
4	176.4734	1.0000	189.1586	0.9994	256
5	230.6241	1.0000	250.4344	0.9984	320
6	288.8474	0.9999	318.0994	0.9939	384
7	348.6964	0.9998	389.5857	0.9784	448
8	385.5980	1.0000	434.9219	0.9941	512
9	440.6855	1.0000	504.5913	0.9853	576
10	483.4327	1.0000	560.2922	0.9895	640
11	527.5948	1.0000	619.6351	0.9900	704
12	576.4012	1.0000	687.3344	0.9829	768

*The test is valid only for lags larger than the System lag order.
df is degrees of freedom for (approximate) chi-square distribution
*df and Prob. may not be valid for models with lagged endogenous...

Wald Test:
System: {%system}

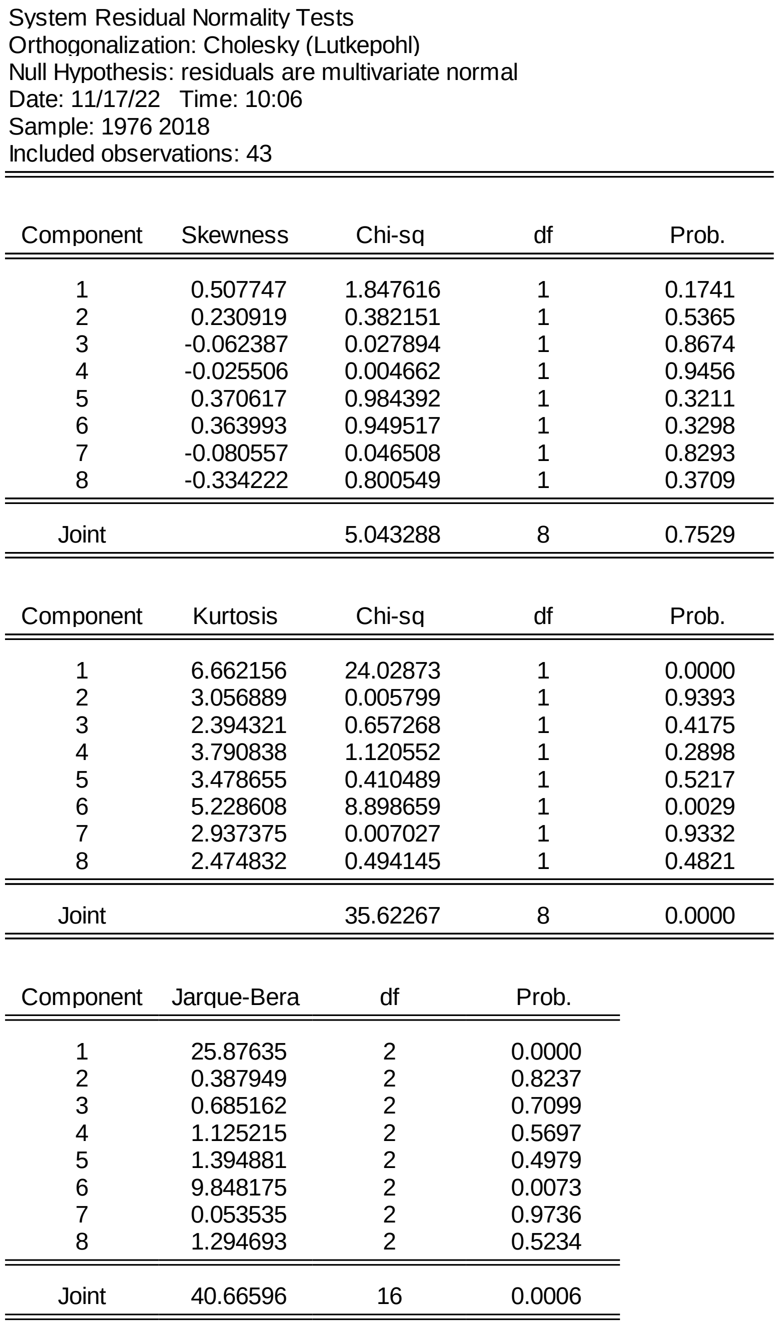
Test Statistic	Value	df	Probability
Chi-square	228.4113	15	0.0000

Null Hypothesis: C(1)=C(2)=C(3)=C(5)=C(8)=C(9)=C(14)
=C(24)=C(45)=C(46)=C(51)=C(52)=C(58)=C(64)=C
(69)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.488137	0.084064
C(2)	-1.974673	0.577600
C(3)	-0.850443	0.422616
C(5)	-0.199481	0.041032
C(8)	-0.656167	0.200507
C(9)	0.022327	0.003369
C(14)	0.040803	0.011694
C(24)	0.288637	0.120754
C(45)	0.046882	0.015910
C(46)	0.108908	0.039505
C(51)	-0.401316	0.152573
C(52)	-0.146780	0.062864
C(58)	3.623514	1.187008
C(64)	0.169112	0.065347
C(69)	-0.697141	0.252377

Restrictions are linear in coefficients.

Table 28: Model 2 Wald Test



System Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 11/17/22 Time: 10:06
Sample: 1976 2018
Included observations: 43

Component	Skewness	Chi-sq	df	Prob.
1	0.507747	1.847616	1	0.1741
2	0.230919	0.382151	1	0.5365
3	-0.062387	0.027894	1	0.8674
4	-0.025506	0.004662	1	0.9456
5	0.370617	0.984392	1	0.3211
6	0.363993	0.949517	1	0.3298
7	-0.080557	0.046508	1	0.8293
8	-0.334222	0.800549	1	0.3709
Joint		5.043288	8	0.7529

Component	Kurtosis	Chi-sq	df	Prob.
1	6.662156	24.02873	1	0.0000
2	3.056889	0.005799	1	0.9393
3	2.394321	0.657268	1	0.4175
4	3.790838	1.120552	1	0.2898
5	3.478655	0.410489	1	0.5217
6	5.228608	8.898659	1	0.0029
7	2.937375	0.007027	1	0.9332
8	2.474832	0.494145	1	0.4821
Joint		35.62267	8	0.0000

Component	Jarque-Bera	df	Prob.
1	25.87635	2	0.0000
2	0.387949	2	0.8237
3	0.685162	2	0.7099
4	1.125215	2	0.5697
5	1.394881	2	0.4979
6	9.848175	2	0.0073
7	0.053535	2	0.9736
8	1.294693	2	0.5234
Joint	40.66596	16	0.0006

Table 29: Model 2 System Residual Normality test

Cointegration Analysis and VECM

Although the results of VAR provide information on the short-run relationship between macroeconomic variables, we still do not know how they behave in the long run. The VECM not only set the framework of whether the short-run relationship between variables is persistent, but also allows us to make long term forecasts. At first, we examine for cointegration. Table 30 suggests that, taking into account the Trace Statistic and the Maximal Eigenvalue Statistic, we identify the existence of two cointegrating relationships in the VAR at the 5%. As a result, since both models exhibit two cointegrating relationships we estimate the VEC models which require not only the variables to be linked in the short run, but to be related in the long run due to the existence of cointegration.

Sample (adjusted): 1976 2018
Included observations: 43 after adjustments
Trend assumption: Linear deterministic trend
Series: GDP PIT TOGS PT DEBT GGCE GFCF HSCONS
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.753335	204.3577	159.5297	0.0000
At most 1 *	0.692830	144.1696	125.6154	0.0023
At most 2	0.512566	93.41436	95.75366	0.0717
At most 3	0.393399	62.51456	69.81889	0.1664
At most 4	0.378380	41.01954	47.85613	0.1881
At most 5	0.254775	20.57618	29.79707	0.3846
At most 6	0.125264	7.931235	15.49471	0.4728
At most 7	0.049354	2.176389	3.841465	0.1401

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.753335	60.18814	52.36261	0.0066
At most 1 *	0.692830	50.75521	46.23142	0.0154
At most 2	0.512566	30.89981	40.07757	0.3668
At most 3	0.393399	21.49501	33.87687	0.6466
At most 4	0.378380	20.44336	27.58434	0.3113
At most 5	0.254775	12.64494	21.13162	0.4854
At most 6	0.125264	5.754846	14.26460	0.6449
At most 7	0.049354	2.176389	3.841465	0.1401

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 30: Model 2 Johansen Test

Vector Error Correction Estimation

Vector Error Correction Estimates

Sample (adjusted): 1977 2018
Included observations: 42 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2
GDP(-2)	1.000000	0.000000
PIT(-1)	0.000000	1.000000
TOGS(-1)	-1.806632	-3.138572
	(0.42475)	(0.39191)
	[-4.25338]	[-8.00833]
PT(-1)	-1.249762	-3.347464
	(0.63135)	(0.58254)
	[-1.97951]	[-5.74635]
DEBT(-1)	0.112335	0.101054
	(0.03083)	(0.02844)
	[3.64389]	[3.55261]
GGCE(-1)	-0.634352	-0.642007
	(0.22190)	(0.20475)
	[-2.85869]	[-3.13561]
GFCF(-1)	-0.302284	-0.562600
	(0.10434)	(0.09628)
	[-2.89699]	[-5.84355]
HSCONS(-1)	-0.533734	-0.017388
	(0.18408)	(0.16985)
	[-2.89942]	[-0.10237]
C	0.643938	0.544724

Error Correction:	D(GDP(-1))	D(PIT)	D(TOGS)	D(PT)	D(DEBT)	D(GGCE)	D(GFCF)	D(HSCONS)
CointEq1	-0.441202	0.061223	0.027662	0.020926	-0.783519	0.121280	0.200508	0.164815
	(0.08201)	(0.02962)	(0.03556)	(0.01419)	(0.50746)	(0.05284)	(0.13911)	(0.08602)
	[-5.38016]	[2.06679]	[0.77785]	[1.47464]	[-1.54399]	[2.29502]	[1.44140]	[1.91604]
CointEq2	0.009323	0.040190	0.183377	0.111731	-0.111973	-0.041857	-0.055775	-0.005081
	(0.11245)	(0.04062)	(0.04876)	(0.01946)	(0.69586)	(0.07246)	(0.19075)	(0.11795)
	[0.08291]	[0.98944]	[3.76049]	[5.74207]	[-0.16091]	[-0.57763]	[-0.29240]	[-0.04308]
D(GDP(-2))	-0.048180	-0.001389	-0.046739	-0.004915	-0.073598	-0.025968	-0.065510	0.030580
	(0.08129)	(0.02937)	(0.03525)	(0.01407)	(0.50306)	(0.05239)	(0.13790)	(0.08527)
	[-0.59267]	[-0.04730]	[-1.32580]	[-0.34941]	[-0.14630]	[-0.49571]	[-0.47506]	[0.35862]
D(PIT(-1))	-1.127643	0.235925	-0.332977	0.082975	-4.455502	-0.116712	0.229385	0.383289
	(0.47723)	(0.17239)	(0.20695)	(0.08258)	(2.95317)	(0.30753)	(0.80952)	(0.50058)
	[-2.36291]	[1.36859]	[-1.60896]	[1.00479]	[-1.50872]	[-0.37952]	[0.28336]	[0.76568]
D(TOGS(-1))	-1.370488	0.134479	0.408490	0.197780	0.638131	-0.340913	0.084208	0.578604
	(0.39165)	(0.14147)	(0.16984)	(0.06777)	(2.42357)	(0.25238)	(0.66435)	(0.41081)
	[-3.49930]	[0.95058]	[2.40517]	[2.91838]	[0.26330]	[-1.35080]	[0.12675]	[1.40843]
D(PT(-1))	0.700912	0.018594	0.046156	-0.192149	-4.297480	0.366538	3.699659	-0.452267
	(0.76246)	(0.27542)	(0.33064)	(0.13194)	(4.71822)	(0.49133)	(1.29336)	(0.79977)
	[0.91928]	[0.06751]	[0.13960]	[-1.45638]	[-0.91083]	[0.74601]	[2.86050]	[-0.56549]
D(DEBT(-1))	-0.121517	0.044129	-0.006395	-0.009034	-0.237818	-0.009333	-0.075163	0.014642
	(0.03379)	(0.01221)	(0.01465)	(0.00585)	(0.20910)	(0.02177)	(0.05732)	(0.03544)
	[-3.59625]	[3.61543]	[-0.43642]	[-1.54507]	[-1.13735]	[-0.42863]	[-1.31133]	[0.41309]
D(GGCE(-1))	-0.756185	-0.083788	0.252268	-0.063388	1.182242	-0.379221	-0.319636	-0.657699
	(0.24303)	(0.08779)	(0.10539)	(0.04205)	(1.50392)	(0.15661)	(0.41225)	(0.25492)
	[-3.11148]	[-0.95444]	[2.39363]	[-1.50729]	[0.78611]	[-2.42143]	[-0.77534]	[-2.57997]
D(GFCF(-1))	0.143911	0.071831	0.116879	0.037135	-0.953972	-0.143165	-0.019420	-0.036360
	(0.12404)	(0.04481)	(0.05379)	(0.02146)	(0.76761)	(0.07993)	(0.21042)	(0.13012)
	[1.16015]	[1.60310]	[2.17279]	[1.73006]	[-1.24278]	[-1.79103]	[-0.09229]	[-0.27944]
D(HSCONS(-1))	-1.027051	0.019145	-0.039424	0.047927	0.546771	-0.037136	-0.361503	-0.007994
	(0.16454)	(0.05944)	(0.07135)	(0.02847)	(1.01821)	(0.10603)	(0.27911)	(0.17259)
	[-6.24194]	[0.32211]	[-0.55252]	[1.68330]	[0.53700]	[-0.35024]	[-1.29520]	[-0.04632]
C	0.010960	-0.000773	0.001796	0.000361	0.048403	0.002324	-0.000925	0.001935
	(0.00235)	(0.00085)	(0.00102)	(0.00041)	(0.01457)	(0.00152)	(0.00399)	(0.00247)
	[4.65557]	[-0.90937]	[1.75904]	[0.88711]	[3.32245]	[1.53179]	[-0.23150]	[0.78348]
R-squared	0.839539	0.415345	0.452133	0.590742	0.245288	0.365946	0.350294	0.292219
Adj. R-squared	0.787777	0.226747	0.275402	0.458723	0.001832	0.161412	0.140711	0.063903
Sum sq. resids	0.004426	0.000577	0.000832	0.000133	0.169473	0.001838	0.012735	0.004869
S.E. equation	0.011948	0.004316	0.005181	0.002068	0.073938	0.007700	0.020268	0.012533
F-statistic	16.21931	2.202273	2.558311	4.474685	1.007526	1.789173	1.671387	1.279887
Log likelihood	132.7229	175.4898	167.8142	206.4004	56.17195	151.1788	110.5278	130.7160
Akaike AIC	-5.796327	-7.832849	-7.467345	-9.304782	-2.151045	-6.675179	-4.739421	-5.700764
Schwarz SC	-5.341223	-7.377745	-7.012241	-8.849678	-1.695941	-6.220075	-4.284317	-5.245660
Mean dependent	-0.001136	0.001105	0.001683	0.000283	0.040102	0.001240	-0.003581	0.002967
S.D. dependent	0.025936	0.004908	0.006087	0.002810	0.074006	0.008408	0.021865	0.012954

Determinant resid covariance (dof adj.)	8.78E-34
Determinant resid covariance	7.73E-35
Log likelihood	1172.687
Akaike information criterion	-50.88986
Schwarz criterion	-46.58706
Number of coefficients	104

Table 31 VECM Estimation Output and Representation for Model 2

The VECM results are presented in Table 31. The two cointegrated equations summarize the long run behavior of the variables. More specifically, the GDP growth is related negatively with personal income tax and tax on goods and services, debt, government expenditure and household consumption. Moreover, property taxes are related positively with gross fixed capital formation and tax on goods and services. Debt is related positively with personal income taxes. Government consumption expenditures are related positively with tax on goods and services and negatively with household consumption.

Variance Decomposition Analysis

Using the estimated model, which provides information about the long-term relationship of the variables, we also perform a variance decomposition analysis, which allows us to characterize the dynamic behavior of the model. Table 32 shows that the change in real GDP growth in the long run also depends on shocks to other variables. More analytically, the impulse or shock to GDP growth in the short run accounts for 48.82% of the variation in GDP growth (own shock). This means that GDP growth is strongly endogenous while shocks to other variables are strongly exogenous.

Variance Decomposition of GDP(-1):

Period	S.E.	GDP(-1)	PIT	TOGS	PT	DEBT	GGCE	GFCF	HSCONS
1	0.011948	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.028520	49.12954	0.478115	14.33554	3.163061	17.32636	2.926868	4.422489	8.218028
3	0.035183	48.82747	1.927527	12.96186	2.113120	19.69573	1.928322	6.637492	5.908477
4	0.038583	49.02614	3.416052	12.05310	1.963705	18.43858	3.548027	6.557833	4.996568
5	0.040491	49.52110	3.803220	12.44037	1.811639	17.06393	4.228541	6.531763	4.599432
6	0.041605	49.19129	4.199952	13.42327	1.720413	16.55059	4.287073	6.263860	4.363552
7	0.042306	49.16566	4.734311	13.23877	1.664124	16.38149	4.316210	6.107544	4.391898
8	0.042877	49.26311	5.145803	12.88865	1.639930	16.11454	4.410263	6.044259	4.493439
9	0.043366	49.45978	5.428047	12.60487	1.604169	15.89042	4.478052	5.986720	4.547943
10	0.043809	49.57996	5.717614	12.43558	1.572800	15.70101	4.516889	5.889081	4.587066

Variance Decomposition of PIT:

Period	S.E.	GDP(-1)	PIT	TOGS	PT	DEBT	GGCE	GFCF	HSCONS
1	0.004316	2.103443	97.89656	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.006679	1.167152	74.58062	0.588178	3.536206	16.19461	3.373821	0.511005	0.048412
3	0.007891	0.853545	71.02819	0.432660	3.210116	20.17967	3.481177	0.441116	0.373527
4	0.008884	0.675633	71.15822	0.345536	3.007471	21.12081	2.971889	0.354488	0.365954
5	0.009848	0.552296	70.84185	0.493893	3.108835	21.63859	2.763353	0.299415	0.301766
6	0.010727	0.466251	70.08386	0.745088	3.159386	22.31189	2.670085	0.298319	0.265118
7	0.011513	0.405453	69.69564	0.791727	3.156045	22.82332	2.577260	0.287871	0.262679
8	0.012244	0.358484	69.57305	0.762682	3.115812	23.16544	2.500233	0.265181	0.259120
9	0.012941	0.320916	69.45936	0.749422	3.098829	23.43211	2.442465	0.246832	0.250073
10	0.013603	0.290478	69.33430	0.772967	3.101846	23.62894	2.393868	0.237783	0.239819

Variance Decomposition of TOGS:

Period	S.E.	GDP(-1)	PIT	TOGS	PT	DEBT	GGCE	GFCF	HSCONS
1	0.005181	1.034780	0.114583	98.85064	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.007213	2.279074	2.685239	88.97489	2.381945	1.627622	1.275705	0.100825	0.674701
3	0.008431	9.014517	3.011451	72.91415	4.198158	2.910384	3.325477	3.579198	1.046665
4	0.009910	15.56377	2.787435	59.69386	5.581934	3.980378	4.263600	7.337239	0.791780
5	0.011656	18.90042	2.601344	55.70440	4.870947	4.500452	4.879734	7.693098	0.849606
6	0.013459	19.59206	2.541129	56.19644	4.139548	4.465529	5.138137	6.971758	0.955399
7	0.014963	20.16009	2.583616	55.79063	3.848877	4.688186	5.261692	6.756769	0.910140
8	0.016215	21.11665	2.663097	53.98401	3.902552	4.988376	5.427225	7.078996	0.839100
9	0.017393	22.03748	2.688734	52.30112	3.944117	5.150250	5.630421	7.434793	0.813082
10	0.018568	22.56033	2.675131	51.60384	3.854125	5.189385	5.762199	7.518942	0.836041

Variance Decomposition of PT:

Period	S.E.	GDP(-1)	PIT	TOGS	PT	DEBT	GGCE	GFCF	HSCONS
1	0.002068	0.279733	5.804546	5.517246	88.39847	0.000000	0.000000	0.000000	0.000000
2	0.002931	0.763847	10.77124	13.26815	60.56306	0.055452	9.535515	3.537905	1.504830
3	0.004015	4.693879	9.895245	19.48097	43.01464	6.457915	8.803116	6.345301	1.308935
4	0.004934	10.86823	8.875249	17.78991	35.60223	7.870767	6.902059	9.464670	2.626887
5	0.005771	15.52809	8.324439	13.16336	32.79684	9.017076	5.473138	10.43855	5.258509
6	0.006553	18.50169	7.560042	10.25237	31.15685	10.36869	4.659328	10.65038	6.850655
7	0.007251	20.87599	6.897273	8.377806	29.40632	11.57498	4.070517	11.22250	7.574613
8	0.007925	22.90140	6.390122	7.106777	27.65880	12.31218	3.571016	12.05845	8.001259
9	0.008569	24.48098	6.017146	6.110563	26.33177	12.73563	3.171806	12.65471	8.497391
10	0.009171	25.61862	5.724343	5.336432	25.50703	13.04577	2.870215	12.91515	8.982447

Variance Decomposition of DEBT:

Period	S.E.	GDP(-1)	PIT	TOGS	PT	DEBT	GGCE	GFCF	HSCONS
1	0.073938	16.85912	7.639429	7.390991	13.91434	54.19612	0.000000	0.000000	0.000000
2	0.108949	24.71502	11.07783	12.36786	8.178968	39.47007	2.150810	1.199515	0.839923
3	0.142170	26.92246	10.57246	16.62651	6.211262	32.73199	3.333100	1.757956	1.844256
4	0.171531	27.46159	10.47424	19.31342	5.254200	29.76324	3.500836	1.966910	2.265561
5	0.196561	27.82803	10.65759	20.40248	4.612480	28.26119	3.745376	2.098787	2.394060
6	0.218416	28.27400	10.77600	20.78054	4.208505	27.25448	3.967932	2.264827	2.473711
7	0.238384	28.54735	10.81488	21.13189	3.935870	26.52331	4.107915	2.374447	2.564343
8	0.256947	28.66911	10.84257	21.51482	3.754113	25.97403	4.195141	2.422105	2.628111
9	0.274182	28.73906	10.87927	21.82662	3.615846	25.55796	4.263543	2.449185	2.668521
10	0.290264	28.81448	10.91497	22.01709	3.505093	25.25678	4.318360	2.479511	2.693714

Variance Decomposition of GGCE:

Period	S.E.	GDP(-1)	PIT	TOGS	PT	DEBT	GGCE	GFCF	HSCONS
1	0.007700	0.037025	5.009767	0.212689	1.676674	5.465524	87.59832	0.000000	0.000000
2	0.009824	0.408295	4.695836	5.555612	1.238539	4.179586	78.77845	4.013452	1.130230
3	0.011744	0.622313	4.001767	6.772707	3.073732	3.030184	77.83584	3.435844	1.227618
4	0.013289	1.515343	3.784925	7.075201	2.675172	2.472926	77.60982	2.712164	2.154451
5	0.014734	3.612593	3.724883	6.897421	2.638010	2.416681	75.66419	2.273225	2.772997
6	0.016185	5.608230	3.699116	8.225629	2.517407	2.240941	71.76377	1.941549	4.003356
7	0.017716	7.046473	3.615760	10.55872	2.593069	2.152448	67.36338	1.640971	5.029180
8	0.019141	8.069556	3.637849	12.28021	2.564429	2.142483	64.20578	1.425292	5.674392
9	0.020394	9.029270	3.699551	13.04148	2.498110	2.180271	62.16105	1.304129	6.086140
10	0.021562	9.909347	3.737636	13.50418	2.431209	2.197353	60.51588	1.233913	6.470474

Variance Decomposition of GFCF:

Period	S.E.	GDP(-1)	PIT	TOGS	PT	DEBT	GGCE	GFCF	HSCONS
1	0.020268	38.91142	3.890875	0.757161	0.167601	0.045836	6.352746	49.87436	0.000000
2	0.032875	39.30943	1.496496	4.926470	2.035356	2.600755	8.087452	39.38711	2.156931
3	0.044190	39.69456	0.852821	9.347892	1.305293	2.461585	9.682384	34.10915	2.546315
4	0.053710	37.83119	0.627274	14.44739	1.174302	2.003001	10.47308	30.18021	3.263540
5	0.061252	37.10961	0.527828	16.63370	1.061731	1.943449	10.77651	28.65505	3.292120
6	0.067577	36.98530	0.485428	16.78064	1.159978	1.890010	11.07307	28.42747	3.198105
7	0.073362	37.01689	0.442016	16.53176	1.221123	1.820183	11.37837	28.44964	3.140018
8	0.078774	36.91598	0.404827	16.73088	1.227275	1.738747	11.57260	28.24495	3.164745
9	0.083795	36.73215	0.378418	17.19210	1.210366	1.681452	11.69691	27.92191	3.186691
10	0.088432	36.60882	0.360768	17.47394	1.210597	1.644033	11.79868	27.72917	3.173988

Variance Decomposition of HSCONS:

Period	S.E.	GDP(-1)	PIT	TOGS	PT	DEBT	GGCE	GFCF	HSCONS
1	0.012533	3.166141	0.286795	9.322662	12.15944	2.679829	0.000199	4.495566	67.88937
2	0.018530	2.071922	0.425474	14.17648	10.92919	2.768891	7.362376	5.820995	56.44468
3	0.021612	1.525658	1.783044	16.62760	9.463410	3.387667	7.522152	4.543595	55.14688
4	0.023847	1.290992	2.108187	16.51470	9.912936	2.955944	7.316391	4.392672	55.50818
5	0.026153	1.074886	2.081955	16.47714	9.631953	2.666089	7.606445	4.228029	56.23350
6	0.028192	0.925812	2.150120	16.33052	9.729358	2.660343	8.053374	4.050254	56.10022
7	0.030015	0.817049	2.247444	16.21937	9.686910	2.549123	8.241789	3.919291	56.31902
8	0.031777	0.729257	2.271171	16.17170	9.723681	2.447518	8.372224	3.813533	56.47091
9	0.033465	0.657564	2.293690	16.16105	9.734708	2.380995	8.531691	3.712738	56.52757
10	0.035044	0.599659	2.324268	16.11520	9.746033	2.334426	8.663040	3.636202	56.58117

Cholesky One S.D. (d.f. adjusted)
Cholesky ordering: GDP(-1) PIT TOGS PT DEBT GGCE GFCF HSCONS

Table 32: Variance Decomposition

5.Taxation, Government Spending, Debt and Growth

In this section we estimate vector autoregressive model (VAR Model 3) VAR (1,1) and examine the short-run relationship among real GDP growth, debt, general government consumption expenditure and tax rate. All the endogenous variable are the differenced time series except for lagged growth to avoid non-stationarity issues. Also, it is obvious that our variables are connected with short-run relationship. Our estimation result suggests that debt, government spending and the level of taxation are negatively[17] correlated with GDP growth while lagged GDP growth is positively correlated with GDP growth of current period. Our analysis reveals that tax revenue (-0,77%), government spending (-0,87%) and debt ratio (-0,19%) have strong negative relationship with growth and tax revenue and government spending are more harmful to growth than debt ratio. This can be explained by the fact that poor tax collection and increased government spending are crucial factor for debt sustainability and thus policies should focus on preventive rationalization measures and adopt a strategy that limit government spending and maintain revenue capacity to a level not harmful to GDP growth as well as debt.

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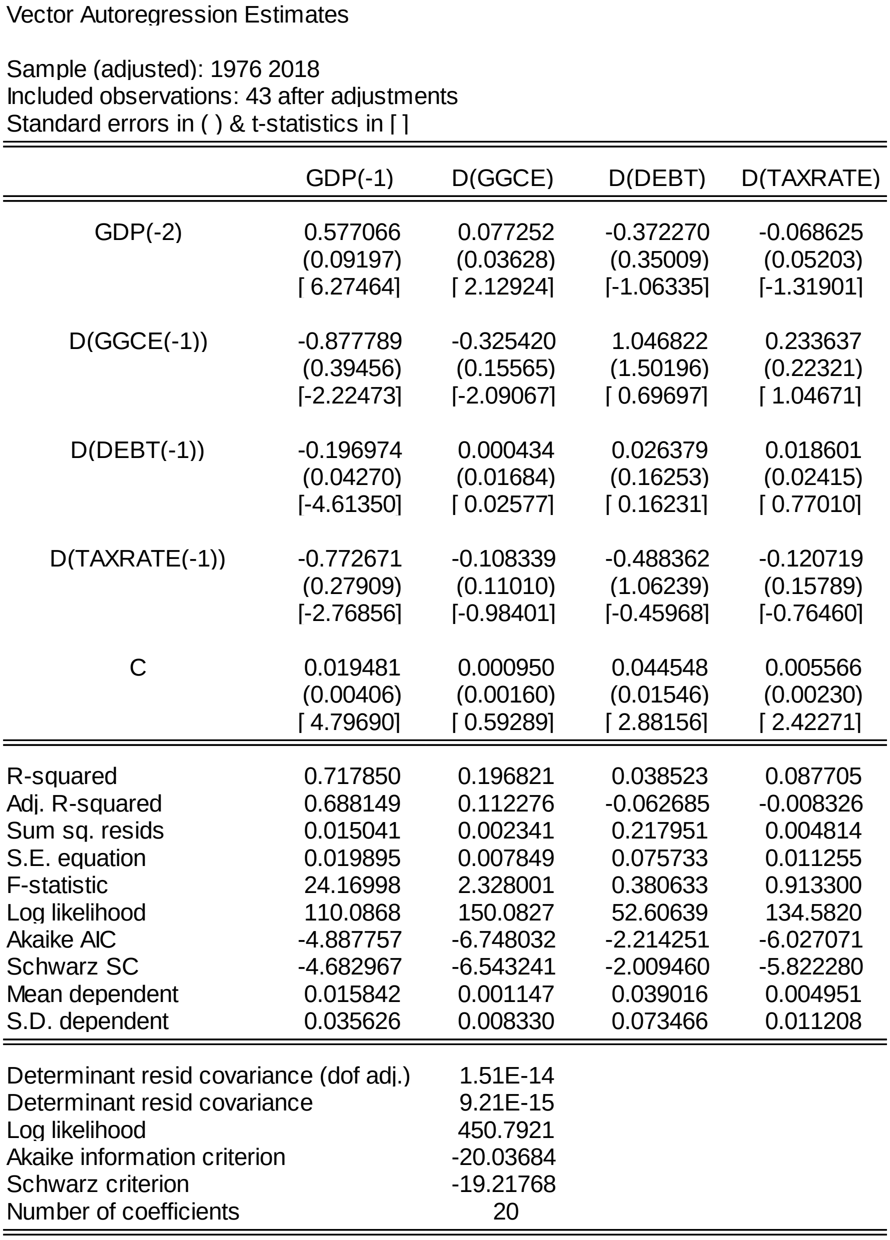
[17] t > 2, i.e., statistically significant coefficient at 5% level.



Vector Autoregression Estimates

Sample (adjusted): 1976 2018
Included observations: 43 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	GDP(-1)	D(GGCE)	D(DEBT)	D(TAXRATE)
GDP(-2)	0.577066	0.077252	-0.372270	-0.068625
	(0.09197)	(0.03628)	(0.35009)	(0.05203)
	[6.27464]	[2.12924]	[-1.06335]	[-1.31901]
D(GGCE(-1))	-0.877789	-0.325420	1.046822	0.233637
	(0.39456)	(0.15565)	(1.50196)	(0.22321)
	[-2.22473]	[-2.09067]	[0.69697]	[1.04671]
D(DEBT(-1))	-0.196974	0.000434	0.026379	0.018601
	(0.04270)	(0.01684)	(0.16253)	(0.02415)
	[-4.61350]	[0.02577]	[0.16231]	[0.77010]
D(TAXRATE(-1))	-0.772671	-0.108339	-0.488362	-0.120719
	(0.27909)	(0.11010)	(1.06239)	(0.15789)
	[-2.76856]	[-0.98401]	[-0.45968]	[-0.76460]
C	0.019481	0.000950	0.044548	0.005566
	(0.00406)	(0.00160)	(0.01546)	(0.00230)
	[4.79690]	[0.59289]	[2.88156]	[2.42271]
R-squared	0.717850	0.196821	0.038523	0.087705
Adj. R-squared	0.688149	0.112276	-0.062685	-0.008326
Sum sq. resids	0.015041	0.002341	0.217951	0.004814
S.E. equation	0.019895	0.007849	0.075733	0.011255
F-statistic	24.16998	2.328001	0.380633	0.913300
Log likelihood	110.0868	150.0827	52.60639	134.5820
Akaike AIC	-4.887757	-6.748032	-2.214251	-6.027071
Schwarz SC	-4.682967	-6.543241	-2.009460	-5.822280
Mean dependent	0.015842	0.001147	0.039016	0.004951
S.D. dependent	0.035626	0.008330	0.073466	0.011208

Determinant resid covariance (dof adj.)	1.51E-14
Determinant resid covariance	9.21E-15
Log likelihood	450.7921
Akaike information criterion	-20.03684
Schwarz criterion	-19.21768
Number of coefficients	20

The model specification is as follows:

Table 32: Model 3 Estimation and Specification

Diagnostics Tests of VAR Model 3

As for the stability condition, we can confirm, as shown in the figure below, that all the roots of the characteristic polynomial lie in the unit circle, so that the variables of the model VAR are stationary. Also from the VAR Lag Order Selection Criteria, the indicated lag order is the lag one (1).

Roots of Characteristic Polynomial
Endogenous variables: GDP(-1) D(GGCE)
D(DEBT) D(TAXRATE)
Exogenous variables: C
Lag specification: 1 1

Root	Modulus
0.634909	0.634909
-0.311810	0.311810
-0.082897 - 0.073161i	0.110564
-0.082897 + 0.073161i	0.110564

No root lies outside the unit circle.
VAR satisfies the stability condition.

Table 33: Model 3 VAR Roots of characteristic polynomial

VAR Lag Order Selection Criteria
Endogenous variables: GDP(-1) D(GGCE) D(DEBT) D(TAXRATE)
Exogenous variables: C

Sample: 1974 2018
Included observations: 41

Lag	LogL	LR	FPE	AIC	SC	HQ
0	397.2061	NA	5.50e-14	-19.18078	-19.01361	-19.11991
1	432.9653	62.79675*	2.11e-14*	-20.14465*	-19.30876*	-19.84027*
2	440.1526	11.21924	3.32e-14	-19.71476	-18.21016	-19.16687
3	450.9554	14.75492	4.54e-14	-19.46124	-17.28793	-18.66984

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 34: Model 3 VAR Lag Order Criteria

Also, VAR results should be tested for residual autocorrelation and normality. From the below tables we can confirm that there is no autocorrelation between residuals. Moreover, since the p-value is 0,1162>0,05 we cannot reject the null hypothesis which means that we can confirm the heteroscedasticity of residuals.

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h

Sample: 1974 2018
Included observations: 43

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	2.856603	---	2.924617	---	---
2	12.23855	0.7274	12.76422	0.6899	16

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

VAR Residual Serial Correlation LM Tests

Sample: 1974 2018
Included observations: 43

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	18.40565	16	0.3007	1.174084	(16, 95.3)	0.3028
2	9.106932	16	0.9089	0.554561	(16, 95.3)	0.9095

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	18.40565	16	0.3007	1.174084	(16, 95.3)	0.3028
2	27.18634	32	0.7089	0.833616	(32, 101.2)	0.7163

*Edgeworth expansion corrected likelihood ratio statistic.

Table 35: Model 3 VAR Autocorrelation test

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal

Sample: 1974 2018
Included observations: 43

Component	Skewness	Chi-sq	df	Prob.*
1	0.487822	1.705452	1	0.1916
2	0.197669	0.280025	1	0.5967
3	0.317266	0.721379	1	0.3957
4	-0.370090	0.981592	1	0.3218
Joint		3.688447	4	0.4498

Component	Kurtosis	Chi-sq	df	Prob.
1	3.867958	1.349755	1	0.2453
2	5.601857	12.12898	1	0.0005
3	6.656152	23.95001	1	0.0000
4	2.715599	0.144917	1	0.7034
Joint		37.57365	4	0.0000

Component	Jarque-Bera	df	Prob.
1	3.055207	2	0.2171
2	12.40900	2	0.0020
3	24.67139	2	0.0000
4	1.126508	2	0.5694
Joint	41.26210	8	0.0000

*Approximate p-values do not account for coefficient estimation

Table 36: Model 3 VAR Normality test

VAR Residual Heteroskedasticity Tests (Levels and Squares)

Sample: 1974 2018
Included observations: 43

Joint test:

Chi-sq	df	Prob.
95.32792	80	0.1162

Individual components:

Dependent	R-squared	F(8,34)	Prob.	Chi-sq(8)	Prob.
res1*res1	0.271266	1.582032	0.1669	11.66444	0.1668
res2*res2	0.109231	0.521158	0.8321	4.696927	0.7894
res3*res3	0.505742	4.348744	0.0011	21.74690	0.0054
res4*res4	0.027438	0.119901	0.9981	1.179827	0.9968
res2*res1	0.173394	0.891507	0.5341	7.455943	0.4883
res3*res1	0.281328	1.663682	0.1436	12.09709	0.1469
res3*res2	0.210071	1.130229	0.3687	9.033042	0.3395
res4*res1	0.183578	0.955639	0.4858	7.893840	0.4439
res4*res2	0.011065	0.047554	0.9999	0.475814	0.9999
res4*res3	0.125995	0.612672	0.7609	5.417781	0.7121

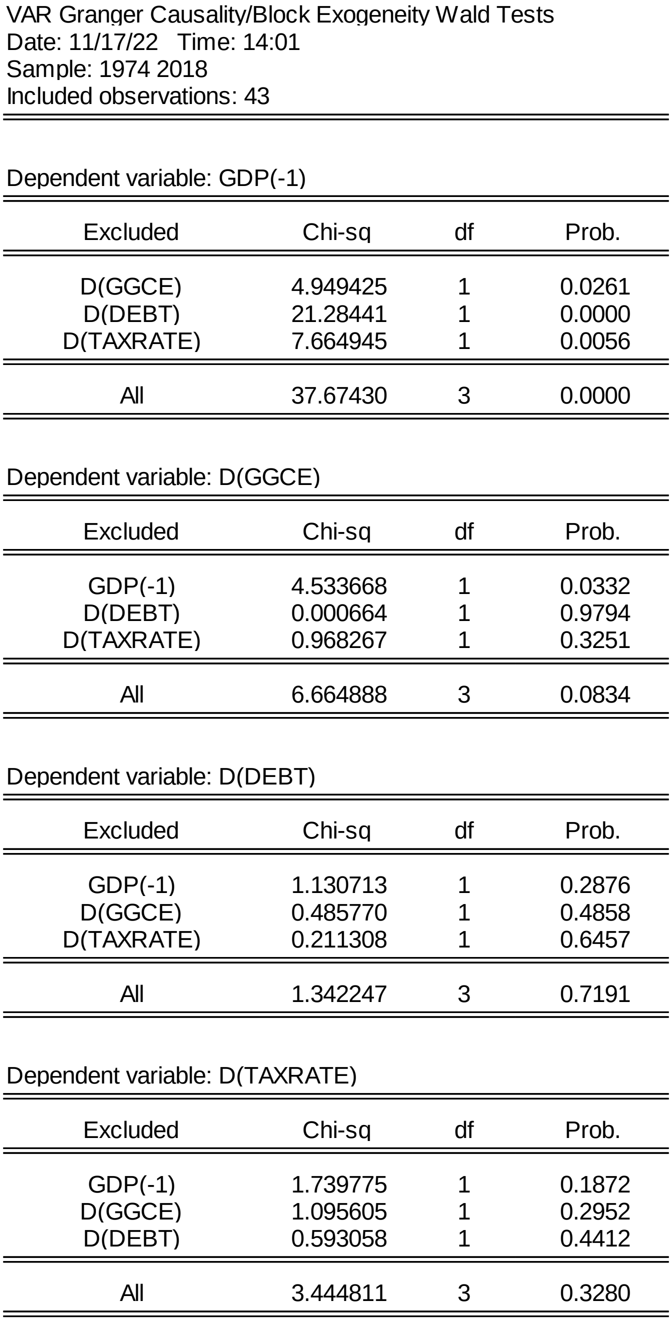
Table 37: Model 3 VAR Heteroskedasticity test

Granger Causality Tests

In addition, we performed a Granger causality test to examine the causal relationship between the endogenous variables. The results presented in the below table, demonstrate the existence of a short-run relationship between the variables. The null hypothesis states that the excluded variable has no Granger causality with the equation variable[18], and the ALL states that all endogenous variables except those of the dependent variable are jointly zero.

---

[18] $p<5\%$ we reject the null hypothesis



VAR Granger Causality/Block Exogeneity Wald Tests
Date: 11/17/22 Time: 14:01
Sample: 1974 2018
Included observations: 43

Dependent variable: GDP(-1)

Excluded	Chi-sq	df	Prob.
D(GGCE)	4.949425	1	0.0261
D(DEBT)	21.28441	1	0.0000
D(TAXRATE)	7.664945	1	0.0056
All	37.67430	3	0.0000

Dependent variable: D(GGCE)

Excluded	Chi-sq	df	Prob.
GDP(-1)	4.533668	1	0.0332
D(DEBT)	0.000664	1	0.9794
D(TAXRATE)	0.968267	1	0.3251
All	6.664888	3	0.0834

Dependent variable: D(DEBT)

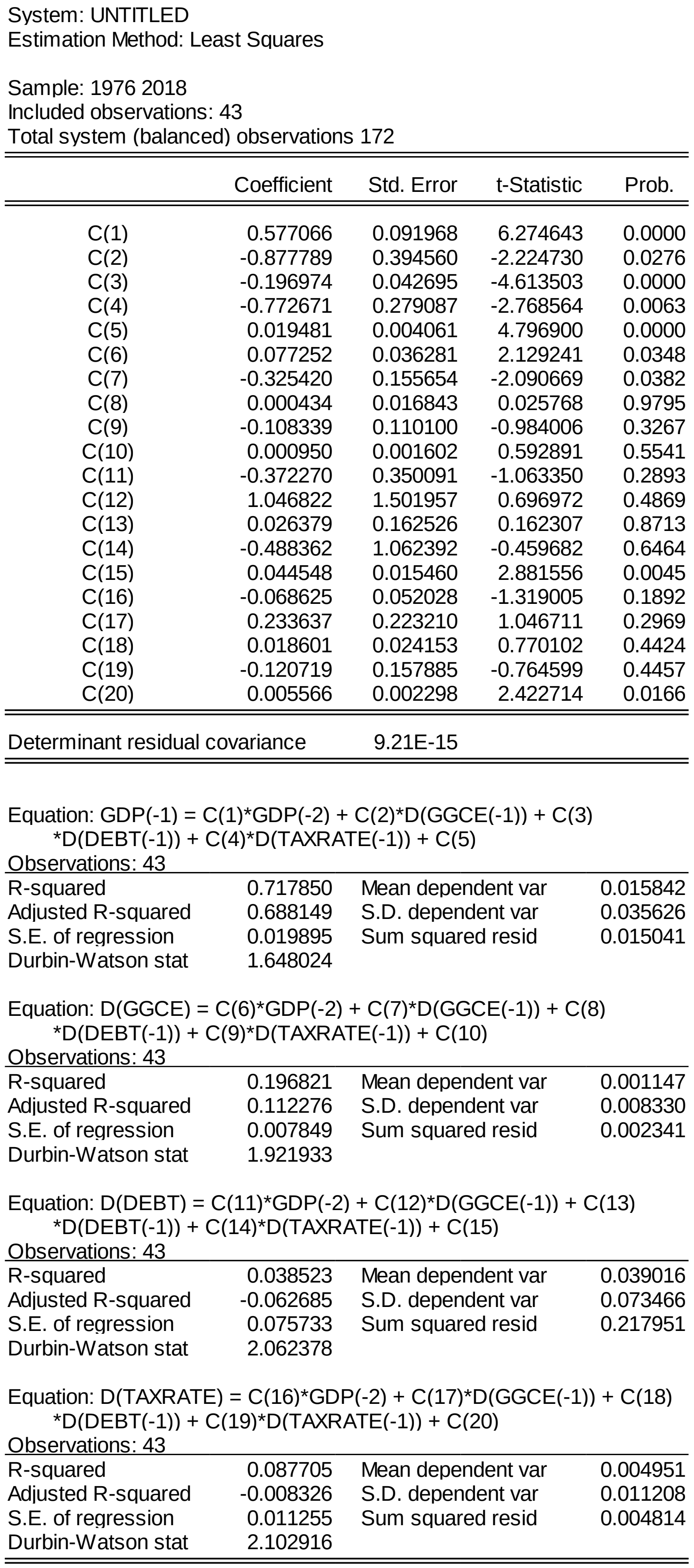
Excluded	Chi-sq	df	Prob.
GDP(-1)	1.130713	1	0.2876
D(GGCE)	0.485770	1	0.4858
D(TAXRATE)	0.211308	1	0.6457
All	1.342247	3	0.7191

Dependent variable: D(TAXRATE)

Excluded	Chi-sq	df	Prob.
GDP(-1)	1.739775	1	0.1872
D(GGCE)	1.095605	1	0.2952
D(DEBT)	0.593058	1	0.4412
All	3.444811	3	0.3280

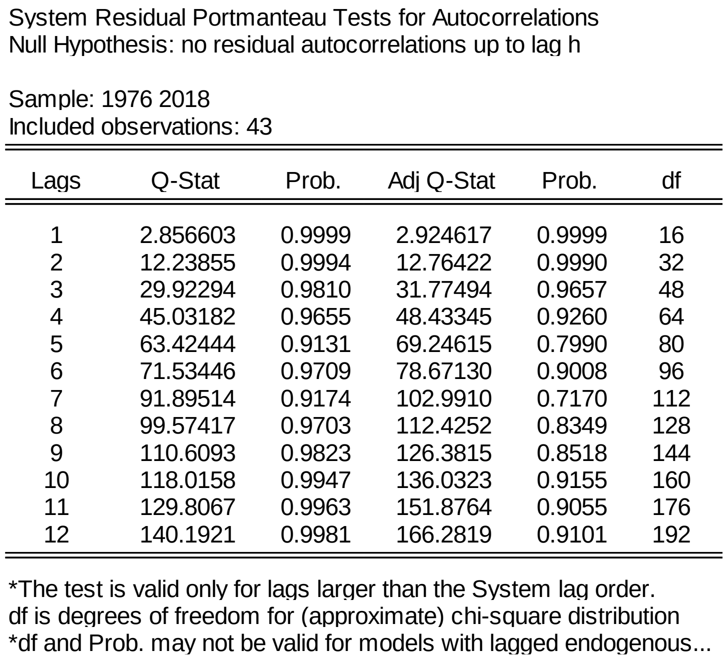
Table 38: Model 3 VAR Granger Causality/Block Exogeneity Tests

Systems Equations and Impulses Response Functions



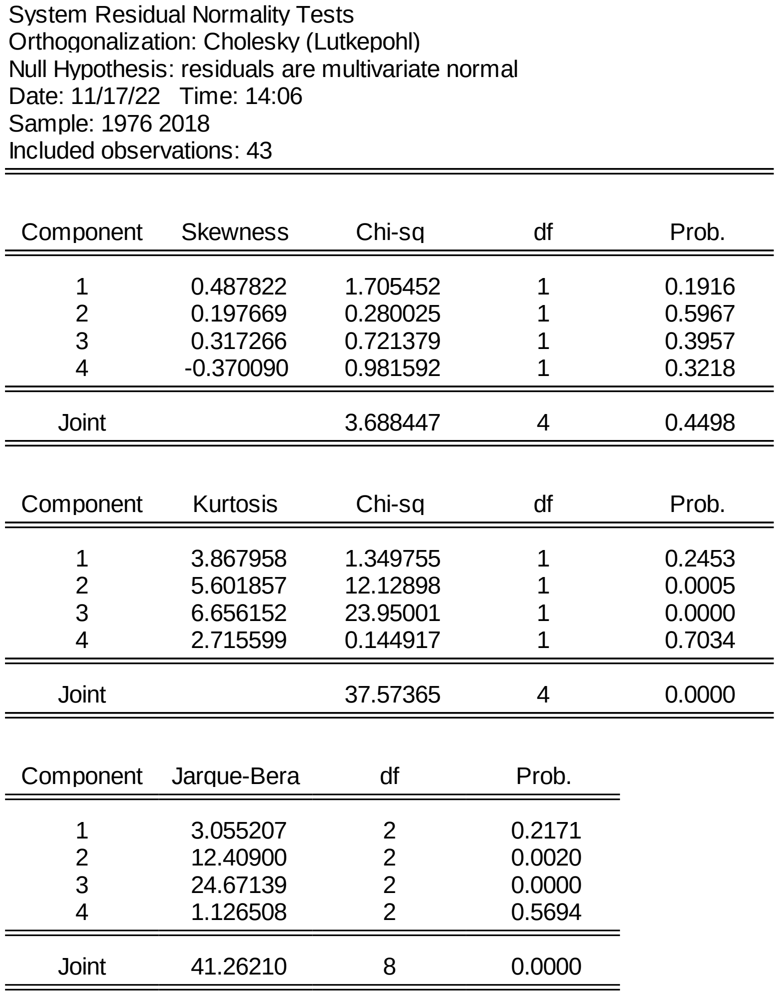
```
System: UNTITLED
Estimation Method: Least Squares

Sample: 1976 2018
Included observations: 43
Total system (balanced) observations 172
====================================================================
                     Coefficient    Std. Error    t-Statistic   Prob.
====================================================================

         C(1)          0.577066      0.091968      6.274643    0.0000
         C(2)         -0.877789      0.394560     -2.224730    0.0276
         C(3)         -0.196974      0.042695     -4.613503    0.0000
         C(4)         -0.772671      0.279087     -2.768564    0.0063
         C(5)          0.019481      0.004061      4.796900    0.0000
         C(6)          0.077252      0.036281      2.129241    0.0348
         C(7)         -0.325420      0.155654     -2.090669    0.0382
         C(8)          0.000434      0.016843      0.025768    0.9795
         C(9)         -0.108339      0.110100     -0.984006    0.3267
        C(10)          0.000950      0.001602      0.592891    0.5541
        C(11)         -0.372270      0.350091     -1.063350    0.2893
        C(12)          1.046822      1.501957      0.696972    0.4869
        C(13)          0.026379      0.162526      0.162307    0.8713
        C(14)         -0.488362      1.062392     -0.459682    0.6464
        C(15)          0.044548      0.015460      2.881556    0.0045
        C(16)         -0.068625      0.052028     -1.319005    0.1892
        C(17)          0.233637      0.223210      1.046711    0.2969
        C(18)          0.018601      0.024153      0.770102    0.4424
        C(19)         -0.120719      0.157885     -0.764599    0.4457
        C(20)          0.005566      0.002298      2.422714    0.0166
====================================================================

Determinant residual covariance          9.21E-15
====================================================================


Equation: GDP(-1) = C(1)*GDP(-2) + C(2)*D(GGCE(-1)) + C(3)
        *D(DEBT(-1)) + C(4)*D(TAXRATE(-1)) + C(5)
Observations: 43
--------------------------------------------------------------------
R-squared                0.717850   Mean dependent var     0.015842
Adjusted R-squared       0.688149   S.D. dependent var     0.035626
S.E. of regression       0.019895   Sum squared resid      0.015041
Durbin-Watson stat       1.648024

Equation: D(GGCE) = C(6)*GDP(-2) + C(7)*D(GGCE(-1)) + C(8)
        *D(DEBT(-1)) + C(9)*D(TAXRATE(-1)) + C(10)
Observations: 43
--------------------------------------------------------------------
R-squared                0.196821   Mean dependent var     0.001147
Adjusted R-squared       0.112276   S.D. dependent var     0.008330
S.E. of regression       0.007849   Sum squared resid      0.002341
Durbin-Watson stat       1.921933

Equation: D(DEBT) = C(11)*GDP(-2) + C(12)*D(GGCE(-1)) + C(13)
        *D(DEBT(-1)) + C(14)*D(TAXRATE(-1)) + C(15)
Observations: 43
--------------------------------------------------------------------
R-squared                0.038523   Mean dependent var     0.039016
Adjusted R-squared      -0.062685   S.D. dependent var     0.073466
S.E. of regression       0.075733   Sum squared resid      0.217951
Durbin-Watson stat       2.062378

Equation: D(TAXRATE) = C(16)*GDP(-2) + C(17)*D(GGCE(-1)) + C(18)
        *D(DEBT(-1)) + C(19)*D(TAXRATE(-1)) + C(20)
Observations: 43
--------------------------------------------------------------------
R-squared                0.087705   Mean dependent var     0.004951
Adjusted R-squared      -0.008326   S.D. dependent var     0.011208
S.E. of regression       0.011255   Sum squared resid      0.004814
Durbin-Watson stat       2.102916
====================================================================
```

Table 39: Model 3 VAR System Equation



```
System Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h

Sample: 1976 2018
Included observations: 43
==================================================================
  Lags      Q-Stat      Prob.    Adj Q-Stat    Prob.      df
==================================================================

   1       2.856603    0.9999    2.924617    0.9999      16
   2       12.23855    0.9994    12.76422    0.9990      32
   3       29.92294    0.9810    31.77494    0.9657      48
   4       45.03182    0.9655    48.43345    0.9260      64
   5       63.42444    0.9131    69.24615    0.7990      80
   6       71.53446    0.9709    78.67130    0.9008      96
   7       91.89514    0.9174    102.9910    0.7170     112
   8       99.57417    0.9703    112.4252    0.8349     128
   9       110.6093    0.9823    126.3815    0.8518     144
  10       118.0158    0.9947    136.0323    0.9155     160
  11       129.8067    0.9963    151.8764    0.9055     176
  12       140.1921    0.9981    166.2819    0.9101     192
==================================================================

*The test is valid only for lags larger than the System lag order.
df is degrees of freedom for (approximate) chi-square distribution
*df and Prob. may not be valid for models with lagged endogenous...
```

Table 40:Model 3 VAR System Residual Portmanteau Tests for Autocorrelations



```
System Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 11/17/22   Time: 14:06
Sample: 1976 2018
Included observations: 43
=========================================================================


 Component    Skewness      Chi-sq         df            Prob.
=========================================================================

     1        0.487822     1.705452        1             0.1916
     2        0.197669     0.280025        1             0.5967
     3        0.317266     0.721379        1             0.3957
     4       -0.370090     0.981592        1             0.3218
=========================================================================

    Joint                  3.688447        4             0.4498
=========================================================================

 Component    Kurtosis      Chi-sq         df            Prob.
=========================================================================

     1        3.867958     1.349755        1             0.2453
     2        5.601857     12.12898        1             0.0005
     3        6.656152     23.95001        1             0.0000
     4        2.715599     0.144917        1             0.7034
=========================================================================

    Joint                  37.57365        4             0.0000
=========================================================================

 Component  Jarque-Bera      df          Prob.
==========================================================

     1        3.055207       2          0.2171
     2        12.40900       2          0.0020
     3        24.67139       2          0.0000
     4        1.126508       2          0.5694
==========================================================

    Joint     41.26210       8          0.0000
==========================================================
```

Table 41: Model 3 VAR System Residual Normality Tests.

Wald Test:
System: {%system}

Test Statistic	Value	df	Probability
Chi-square	123.9443	5	0.0000

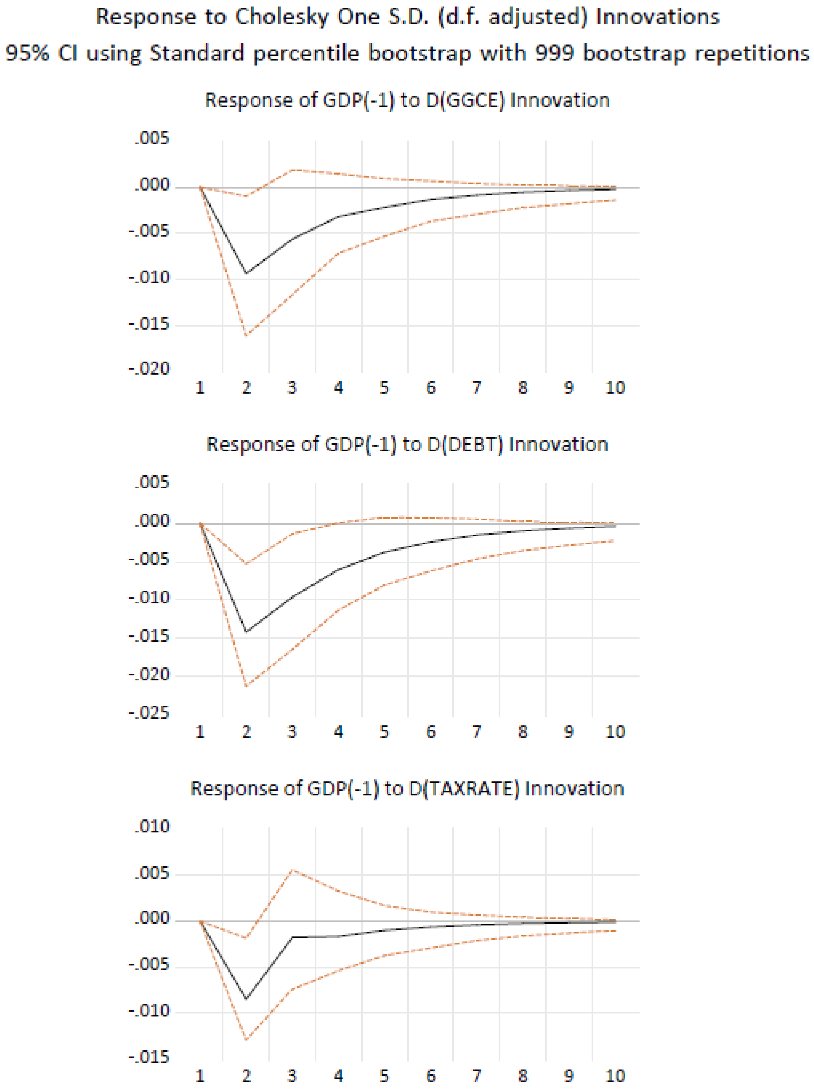
Null Hypothesis: C(1)=C(2)=C(3)=C(4)=C(5)=0
Null Hypothesis Summary:

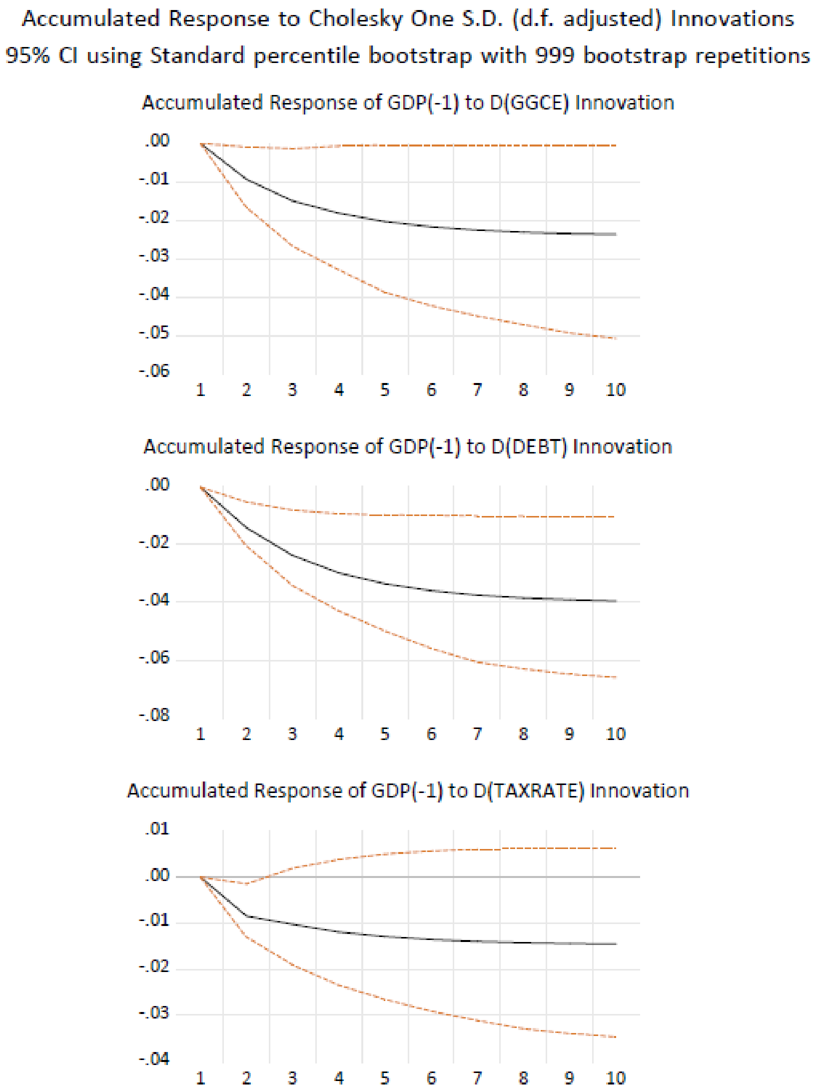
Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.577066	0.091968
C(2)	-0.877789	0.394560
C(3)	-0.196974	0.042695
C(4)	-0.772671	0.279087
C(5)	0.019481	0.004061

Restrictions are linear in coefficients.

Table 42: Model 3 VAR Wald Tests.

Figure 16: Impulse Responses (Accumulated Responses)


Response to Cholesky One S.D. (d.f. adjusted) Innovations
95% CI using Standard percentile bootstrap with 999 bootstrap repetitions
Response of GDP(-1) to D(GGCE) Innovation
.005
.000
-.005
-.010
-.015
-.020
1 2 3 4 5 6 7 8 9 10
Response of GDP(-1) to D(DEBT) Innovation
.005
.000
-.005
-.010
-.015
-.020
-.025
1 2 3 4 5 6 7 8 9 10
Response of GDP(-1) to D(TAXRATE) Innovation
.010
.005
.000
-.005
-.010
-.015
1 2 3 4 5 6 7 8 9 10


Accumulated Response to Cholesky One S.D. (d.f. adjusted) Innovations
95% CI using Standard percentile bootstrap with 999 bootstrap repetitions

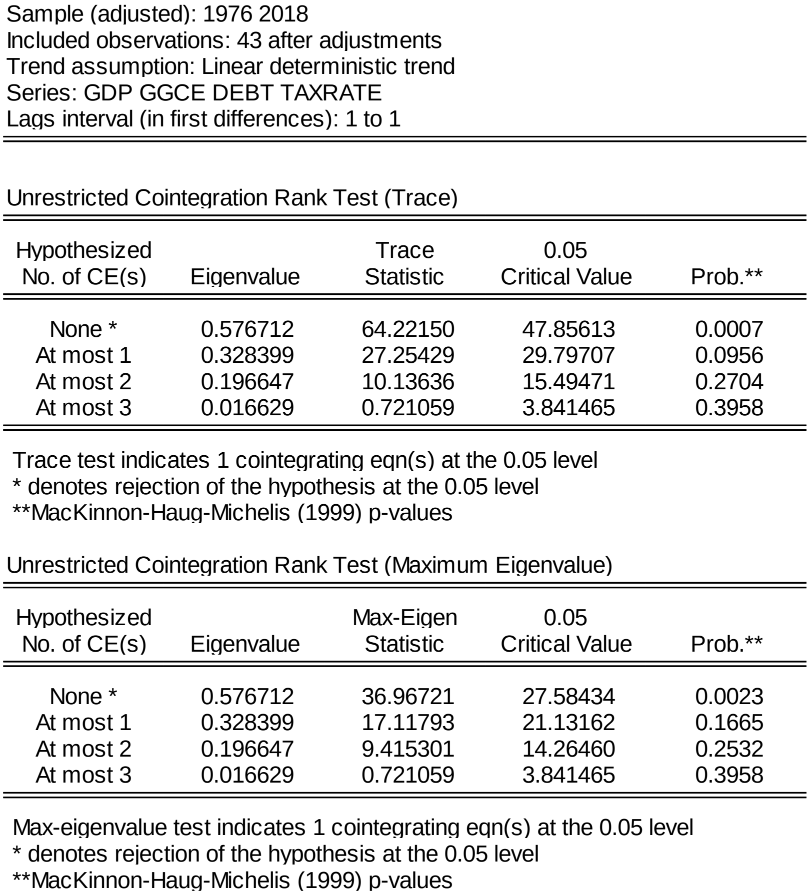
Accumulated Response of GDP(-1) to D(GGCE) Innovation

Accumulated Response of GDP(-1) to D(DEBT) Innovation

Accumulated Response of GDP(-1) to D(TAXRATE) Innovation

VECM and Cointegration

Although the results of VAR provide information on the short-run relationship between macroeconomic variables, we still do not know how they behave in the long run. The VECM not only set the framework of whether the short-run relationship between variables is persistent, but also allows us to make long term forecasts. At first, we examine for cointegration. Table 42 suggests that, taking into account the Trace Statistic and the Maximal Eigenvalue Statistic, we identify the existence of one cointegrating relationship in the VAR at the 5%. As a result, since both models exhibit two cointegrating relationships we estimate the VEC models which require not only the variables to be linked in the short run, but to be related in the long run due to the existence of cointegration.



Sample (adjusted): 1976 2018
Included observations: 43 after adjustments
Trend assumption: Linear deterministic trend
Series: GDP GGCE DEBT TAXRATE
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.576712	64.22150	47.85613	0.0007
At most 1	0.328399	27.25429	29.79707	0.0956
At most 2	0.196647	10.13636	15.49471	0.2704
At most 3	0.016629	0.721059	3.841465	0.3958

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.576712	36.96721	27.58434	0.0023
At most 1	0.328399	17.11793	21.13162	0.1665
At most 2	0.196647	9.415301	14.26460	0.2532
At most 3	0.016629	0.721059	3.841465	0.3958

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 42: Model 3 VAR Cointegration Tests.

Vector Error Correction Estimates

Sample (adjusted): 1977 2018
Included observations: 42 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
GDP(-2)	1.000000
GGCE(-1)	0.893718 (0.32351) [2.76258]
DEBT(-1)	0.084016 (0.02579) [3.25823]
TAXRATE(-1)	-0.853110 (0.25985) [-3.28307]
C	-0.014257

Error Correction:	D(GDP(-1))	D(GGCE)	D(DEBT)	D(TAXRATE)
CointEq1	-0.660353 (0.11628) [-5.67892]	0.077415 (0.06293) [1.23020]	0.067799 (0.58270) [0.11635]	-0.010168 (0.08776) [-0.11586]
D(GDP(-2))	0.140172 (0.09135) [1.53440]	-0.002920 (0.04944) [-0.05907]	-0.582629 (0.45778) [-1.27273]	0.038208 (0.06895) [0.55416]
D(GGCE(-1))	-0.468687 (0.33063) [-1.41755]	-0.334675 (0.17893) [-1.87042]	0.488869 (1.65684) [0.29506]	0.159319 (0.24954) [0.63846]
D(DEBT(-1))	-0.099316 (0.03307) [-3.00333]	-0.011676 (0.01790) [-0.65246]	0.014757 (0.16571) [0.08905]	0.033728 (0.02496) [1.35140]
D(TAXRATE(-1))	-0.995446 (0.22616) [-4.40149]	-0.098566 (0.12239) [-0.80532]	-0.156663 (1.13332) [-0.13823]	-0.100987 (0.17069) [-0.59164]
C	0.008070 (0.00286) [2.81796]	0.002622 (0.00155) [1.69202]	0.040085 (0.01435) [2.79335]	0.003644 (0.00216) [1.68597]
R-squared	0.694411	0.148362	0.057475	0.067222
Adj. R-squared	0.651968	0.030079	-0.073431	-0.062331
Sum sq. resids	0.008428	0.002468	0.211647	0.004801
S.E. equation	0.015301	0.008281	0.076675	0.011548
F-statistic	16.36106	1.254296	0.439058	0.518874
Log likelihood	119.1949	144.9832	51.50521	131.0138
Akaike AIC	-5.390233	-6.618247	-2.166915	-5.953038
Schwarz SC	-5.141995	-6.370009	-1.918676	-5.704800
Mean dependent	-0.001136	0.001240	0.040102	0.004683
S.D. dependent	0.025936	0.008408	0.074006	0.011204

Determinant resid covariance (dof adj.)	1.14E-14
Determinant resid covariance	6.16E-15
Log likelihood	448.7633
Akaike information criterion	-20.03635
Schwarz criterion	-18.87790
Number of coefficients	28

Table 43: Vector Error Estimates

Variance Decomposition of GDP(-1):

Period	S.E.	GDP(-1)	GGCE	DEBT	TAXRATE
1	0.015301	100.0000	0.000000	0.000000	0.000000
2	0.024022	55.30322	15.28498	25.32801	4.083784
3	0.028163	43.05954	17.20349	30.97150	8.765467
4	0.031155	35.55493	16.28493	27.76845	20.39168
5	0.033917	30.04389	14.95041	24.06742	30.93829
6	0.036405	26.11406	13.77145	21.13785	38.97663
7	0.038576	23.32009	12.97128	19.03590	44.67272
8	0.040548	21.19367	12.42758	17.47665	48.90211
9	0.042403	19.47377	12.02522	16.25072	52.25030
10	0.044181	18.02852	11.70163	15.23877	55.03109

Variance Decomposition of GGCE:

Period	S.E.	GDP(-1)	GGCE	DEBT	TAXRATE
1	0.008281	0.073436	99.92656	0.000000	0.000000
2	0.010329	0.585448	95.90683	0.301911	3.205807
3	0.012292	1.190615	91.78200	1.327382	5.700003
4	0.013938	1.685051	88.48992	2.309647	7.515379
5	0.015403	1.969888	86.37621	3.071933	8.581968
6	0.016725	2.133154	85.09126	3.579615	9.195977
7	0.017945	2.231974	84.27258	3.913985	9.581461
8	0.019085	2.300474	83.69564	4.148010	9.855874
9	0.020161	2.353922	83.24950	4.325054	10.07152
10	0.021183	2.398368	82.88335	4.467822	10.25046

Variance Decomposition of DEBT:

Period	S.E.	GDP(-1)	GGCE	DEBT	TAXRATE
1	0.076675	4.168113	0.004487	95.82740	0.000000
2	0.111008	6.805475	0.111646	93.03575	0.047127
3	0.139744	6.338527	0.351891	93.26976	0.039824
4	0.162397	5.772643	0.400309	93.51787	0.309182
5	0.180774	5.353847	0.383864	93.60574	0.656552
6	0.196881	5.049013	0.362408	93.65082	0.937759
7	0.211586	4.837843	0.342821	93.67660	1.142733
8	0.225334	4.687853	0.328133	93.70127	1.282741
9	0.238344	4.575149	0.317493	93.72485	1.382505
10	0.250716	4.485885	0.309487	93.74547	1.459154

Variance Decomposition of TAXRATE:

Period	S.E.	GDP(-1)	GGCE	DEBT	TAXRATE
1	0.011548	2.461348	2.003691	0.889690	94.64527
2	0.016092	2.165807	3.868649	5.070675	88.89487
3	0.019242	1.852403	3.846089	5.666418	88.63509
4	0.022240	1.656917	4.045903	6.178253	88.11893
5	0.024829	1.548980	4.162985	6.592092	87.69594
6	0.027153	1.483566	4.237036	6.838691	87.44071
7	0.029289	1.442024	4.290973	7.011254	87.25575
8	0.031273	1.412411	4.329562	7.136280	87.12175
9	0.033138	1.389390	4.358855	7.231011	87.02074
10	0.034905	1.370646	4.382270	7.306863	86.94022

Cholesky One S.D. (d.f. adjusted)
Cholesky ordering: GDP(-1) GGCE DEBT TAXRATE

Table 44: Variance Decomposition Vector Error Estimates

6.Conclusions

By and large, our main research questions are valid and consistent with the relevant literature. In our literature review, we found that while there is no consensus on the impact of direct and indirect taxation on economic development, most theoretical and empirical studies show a negative relationship between the level of taxation and economic growth. Thus, taxation policies directly affect the performance of an economy and the welfare of its citizens. From a theoretical point of view, taxes cause distortions in the economy, but not all with the same intensity. Taxes that prove to be friendly to economic growth are property taxes and consumption taxes, while income taxes, social security contributions, or corporate profits are more harmful. This result suggests that changing the tax base from the last to the first taxes can promote long-term economic growth. From empirical point of view, we adopted an empirical approach using VAR models to capture the macroeconomic impact of tax changes for the examined period. Therefore, we apply VAR models to focus on the effects of the total tax rate [19] on real GDP growth not only at the overall level but also the effects of personal income tax and tax on goods and services. It is crucial to emphasize that the personal income tax and the tax on goods and services were the main instruments for generating tax revenues during the economic crisis as it has been shown in our relevant analysis in tax revenue trends section. In addition, we examined the dynamic relationship between tax revenues and other national accounts such as gross fixed capital formation, government consumption expenditure, and household consumption. Given the crucial role of government spending and debt sustainability, we also apply a general VAR model that allows us to estimate the impact of tax and government expenditures policies on economic growth.

Therefore, our empirical analysis shows that the tax rate negatively affects GDP growth in the short run. The regression shows that a one percent increase in the tax rate lowers the level of GDP growth by 0,86%. Despite the fact that the results from VAR provide information on the short-run relationship, it is crucial to know their long-run behavior. In this context, a co integration test validated that VAR model is useful both in short and long run. The Granger causality test suggests that GDP growth has no causal effect on tax rate while tax rate has Granger causality with GDP growth. As far as the impulse response analysis is concerned, we find that a one standard deviation shock in the tax rate can lead to an initial substantial decline in GDP growth in the short run. In addition, the effects of a permanent change are given by the cumulative impulse response function which suggest -0,25% decline of future GDP growth to 1% upward shift in total tax rates. It is obvious from our analysis that increases in tax rates have negative effect on economic growth which is consistent with the prediction of neoclassical growth model. The model 1 confirms that tax rates and tax policy in the short-run, as a policy-making tool for overall economic growth, have a Granger causality effect on GDP for the period studied from 1974 to 2018, implying that the setting and structure of taxation is important not only for fiscal consolidation issues but also for the impact on economic development.

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[19] The tax-to-GDP ratio is simply tax revenue/GDP.GDP which is a proxy for total tax rate. Growth is real GDP growth.

In addition, we examine the short-run relationship among real GDP growth, personal income taxes, tax on goods and services, property taxes, debt, general government consumption expenditure, gross fixed capital formation and household consumption. Our estimation result suggests that personal income taxes (-1,97%), tax on goods and services (-0,85%), debt (-0,19%), general government consumption expenditure (-0,54%), and household consumption (-0,65%) are negatively[20] correlated with GDP growth while lagged GDP growth is positively correlated with GDP growth of current period (0,48%). Also, property taxes are positively correlated with gross fixed capital formation (3,62%), debt is positively correlated with personal income tax (0,04%) and government expenditures with tax on goods and services (0,29%). The analysis of the coefficients suggests that income taxes were the most important factor in debt servicing, which had a negative impact on growth, and taxes on goods and services (transaction taxes) served mainly to address difficulties in government spending. Increased government spending and household consumption have a negative effect on growth and investment, while property taxes are positively correlated with investment in fixed assets. Government spending is negatively correlated with gross fixed capital formation (-0.14 %). Also, we conclude that we should apply error correction methods (VECM model 1) to capture long term relationships. Moreover, we focus on examining the short-run relationship among real GDP growth, debt, general government consumption expenditure and tax rates. Our estimation result suggests that debt (-0,19%), government spending (-0,88%) and the level of taxation (-0,77%) are negatively correlated with GDP growth while lagged GDP growth is positively correlated with GDP growth of current period (0,58%). Also, we test for cointegration and we conclude that we should apply error correction methods to capture long term relationships. In this context, policymakers should pursue a strategy that promotes the rationalization of government spending and the sustainability of debt, keeping the revenue capacity at a level that does not harm long-term growth. However, our analysis has limitations. We attempt to capture the overall picture of the changes and the effects based on vector autoregressive model analysis. It is also known that the proposed tax measures were not followed by specific quantification, we are unable to produce a reliable exogenous measure of quantitative impacts tax policy measure. Also, due to the fact that the tax system has undergone many changes and the time period is quite long, we would be better off focusing on periods of fiscal consolidation and other macroeconomic imbalances. Moreover, we attempt to examine the impact on components other than GDP, and we restrict the dataset to 2018, excluding recent developments such as the 2019 elections, the exit from enhanced fiscal surveillance, and Covid-19. An insightful extension is to model the impact of these changes in a forecasting model. Another interesting aspect is that the Greek tax measure database will be a useful tool for policymakers for further study and quantification.

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[20] t > 2, i.e., statistically significant coefficient at 5% level. Government and household consumption expenditures are also negatively correlated, but not with statistical significance at the 5% level

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