Fiscal policy at the zero lower bound:

An analysis of fiscal policy effectiveness in stimulating economic growth

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Abstract:

In 2020, the COVID-19 pandemic caused a global economic decline, and policymakers in the euro area were unsure how to stimulate the economy. Lowering the policy rate was not an option as it was already at its zero lower bound (ZLB), causing a liquidity trap. However, fiscal policy is a powerful alternative for stimulating the economy, particularly in a ZLB, as according to conventional Keynesian theory, fiscal policy should be more efficient at stimulating the economy. Should policymakers in the euro area thus rely more on fiscal policy to boost the economy in a ZLB environment?

This thesis aims to study the difference in the fiscal policy multiplier (fiscal multiplier) during ZLB and non-ZLB periods and what causes the difference. Fiscal policy is defined as changes in government expenditure. The study of government expenditure and the expenditure's ability to stimulate the economy is conducted by analyzing its effects on GDP, inflation, consumption, investment, and the consumer confidence index (CCI). In the thesis panel, vector autoregression (PVAR) is used to estimate the fiscal multiplier for the original EA countries. The timeframe used in the thesis is 1999 to 2021. The analysis is conducted by simulating a shock in government expenditure and measuring the effect on the other variables in the model. The effect on GDP is measured to construct a traditional fiscal multiplier. The analysis of consumption, investment, and CCI is made to deepen the analysis of the phenomena. The subsequent objective of this thesis is to make several contributions to the existing literature, namely: developing a specific multiplier for the EA region, enhancing the accuracy of estimates through the utilization of PVAR and GMM instruments, permitting the assessment of shorter time intervals, exploring the causality of larger multipliers during ZLB periods, and evaluating the efficacy of fiscal policy in promoting the economy's recovery from a liquidity trap or growth recession.

The results show that fiscal policy has a more significant effect during ZLB periods than non-ZLB periods in accordance with the theory. The fiscal multiplier is 1.52 for ZLB periods and 0.30 for non-ZLB periods. While consumers' reaction is essential, the results indicate that investment reaction is of more vital importance since the reaction of investment to expenditure differs the most between periods of and without ZLB. However, Large multipliers are only present during recessionary periods, although the multiplier is more substantial in all scenarios in ZLB periods. Policymakers should undertake fiscal expansions to stimulate demand in ZLB conditions during recessions. However, exercising prudence in non-recessionary periods is essential to prevent crowding out of private investments. The findings suggest that using government expenditure to extricate the economy from a liquidity trap or growth recession is not a dependable strategy, given its ineffectiveness in fostering overall demand.

Keywords: Zero lower bound, fiscal policy, fiscal multiplier, Panel vector auto regression and GMM instruments

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1. Introduction

In the wake of the financial and euro crises, the European Central Bank (ECB) faced the zero lower bound (ZLB) of its policy rates, perplexing economists and European policymakers. In light of this situation, some economists suggested that fiscal policy could be a viable alternative to stimulate the economy in the next crisis. One such economist is the former Federal Reserve chair Ben Bernanke, who stated*, "It would be extremely helpful if central banks could count on other policymakers, particularly fiscal policymakers, to take on some of the burdens of stabilizing the economy during the next recession"* (Ben Bernanke, CNBC. 14 September 2016).

The euro area (EA) has encountered negative GDP growth and elevated levels of unemployment in the aftermath of the financial and euro crises. It was not until 2014 that the region finally attained pre-crisis GDP levels, highlighting the extensive duration of the recovery process. Between 2007 and 2014, the average unemployment rate rose from 7.5% to 11.7% in the EA. The EA has also experienced slower recovery, a more stubbornly low-interest rate, higher unemployment, and more sluggish growth than the United States, Canada, and Australia after the financial crisis. The grimmer economic development in the EA indicates that the union countries face different obstacles than other countries. The EA might even remain in a prolonged growth recession[1].

The Corona pandemic disrupted the global economy at the start of 2020, causing an extensive decline in output and demand. Lowering the policy rate is the primary way a central bank implements monetary policy. However, this approach becomes limited when the policy rate is zero, as it is no longer possible to lower interest rates further to encourage borrowing and investment. Therefore, unconventional monetary policy and fiscal policy were the only viable options for stimulating the economy.

The ECB is responsible for directing the monetary policy of the EA. Its primary objective is to ensure price stability. The ECB's emphasis on price stability implies that the responsibility for

[1] Fabricant (1972) coined the term growth recession. Fabricant (1972) explains that it is a period characterized by such a slow economic growth level that more capacity is being lost than added to an economy.

stimulating the economy in times of crisis primarily falls on the fiscal authorities of individual member countries, potentially resulting in coordination challenges between monetary and fiscal policies within the EA.

ZLB is a macroeconomic phenomenon where the short-term nominal interest rate (policy rate) is zero or near zero. ZLB causes the economy to enter a liquidity trap, limiting the central banks' stimulating ability (Sims, 2018, p. 206). Most developed economies, such as the countries in the EA, experienced ZLB between 2012 and 2021. The policy rate in the EA was virtually zero or even negative between 2013 and 2021, forcing the ECB to adopt alternative methods to raise inflation to its 2% goal, such as Quantitative Easing (QE) and forward guidance (Bernanke, B.S, 2022).

However, there is an ongoing debate about whether methods like QE effectively raise inflation during ZLB. Nobel laureate Milton Friedman (1969, s 5-6) argues that expanding the monetary base would necessarily cause inflation and pushes the economy out of a liquidity trap. Economists such as the Nobel laureate Paul Krugman & et al. (2012, s 286-287) have criticized Friedman's theories and the concept that QE alone is enough to jolt an economy out of a liquidity trap. Krugman conclusions are rooted in Japan and post-financial crisis advanced economies, where monetary expansions have yet to conclude in inflation. Krugman argues that the central problem is an inadequate total demand in the economy.

The ECB has an official inflation target of 2% but has repeatedly failed to reach this goal between 2012 and 2021. As a result, inflation has remained low, leading to a policy rate at the ZLB. In non-ZLB periods the individual EA member countries are forced to use fiscal policy to adjust their economies when the ECB monetary policy is unsuitable for the countries' needs. However, in a ZLB environment, even more, stimulating effects fall on the fiscal policy since conventional monetary policy is less effective. The fiscal authorities should thus help the ECB reach its inflation goal.

Krugman et al. (1998) propose an alternative theory for efficient stimulation during ZLB, namely fiscal policy. Fiscal policy is more efficient during ZLB due to a lack of pressure on the interest rate and the prevailing pessimism of the expected future economic outlook (low demand). Krugman et al. (1998) chose to study the case of Japan in the 1990s, which suffered from a persistent liquidity trap. A liquidity trap is when the nominal interest rates are at or near zero, causing investors to feel indifferent between holding bonds/assets or money (Krugman, 1999). Consequently, monetary policy thus becomes ineffective at stimulating demand and raising inflation. As with the EA countries before the pandemic, the Japanese economy suffered stagnation and deflation.

1.1 Goal of this thesis

The thesis aims to study the difference in the fiscal policy multiplier (fiscal multiplier) between periods of and without ZLB and what essential applications are for policymakers. This thesis seeks to make three key contributions. Firstly, how does ZLB effects the efficiency of fiscal policy? Secondly, how fiscal policy affects the private sector. Thirdly, can sizable fiscal expansion's ability jumpstart the economy? The efficiency of fiscal policy is mainly measured by the sizes of the fiscal multipliers on the GDP and its effect on inflation, private consumption, private investments, and the consumer confidence index. The fiscal multiplier is characterized as the additional effect of fiscal spending on the output.

The current literature on the subject consists of the widespread usage of New Keynesian and New Classical DSGE models such as Johannsen (2014) and Aursland et al. (2020). However, the DSGE models face insufficient empirical support. The deficiency of empirical studies results from the fact that prolonged spells of ZLB were not measured before current times (except in Japan). Bonam et al. (2022) are among the first to make an empirical study of the ZLB following the increase in data in recent years. This thesis is one of the first to study the effects of ZLB using panel vector autoregression (PVAR) model for the EA.

However, Bonam et al. (2022) assume that the policy rate level causes the fundamental difference in the multiplier. Nevertheless, there might be other causes, such as the state of the business cycle, monetary policy differences, and cross-country differences. Bonam et al. (2022) do not seek to explain why the economy reacts as it does. This thesis thus aims to use more unconventional methods to more accurately and with greater certainty estimate the effects of ZLB. This thesis seeks to contribute to the existing literature through a rigorous analysis focused exclusively on the EA, thereby mitigating the influence of cross-country variations. The investigation delves into the analysis of private consumption and investment and employs diverse periods and instrument variables to estimate the causal impact of the multiplier. Such methodological advancements add to the sophistication of the research and deepen our understanding of this complex phenomenon.

The focus is on the original EA countries: Germany, France, Italy, Spain, Finland, the Netherlands, Ireland, Austria, Belgium, and Portugal (notably, Luxemburg has been omitted because of a lack of data). The choice of the countries and the choice of the period is meant to support each other. The choice of the EA has a dual purpose. Firstly, by relinquishing the sovereignty of their independent monetary policy, countries are forced to rely more on fiscal policy to fine-tune their stabilization policy, increasing the importance of the fiscal policy compared to regions that can decide their monetary policy. Secondly, since the fiscal policy is not directly coordinated with the ECB's monetary policy, its effects can be seen as purer and, to a lesser extent, mixed with the effects of monetary policy. The period that is analyzed is 1999-2021. The period is chosen because the EA was created in 1999.

If the multiplier is more prominent during periods of ZLB, policymakers can, with more certainty, confound themselves to using fiscal policy to a more considerable extent to stimulate the economy. A subsequent implication is that economies could end both a liquidity trap and a growth recession by using extensive fiscal expansion. The past ten years have also proven that the ECB needs help reaching its inflation goal of 2%. Since the individual member countries can not affect the monetary policy, the individual countries can help the ECB reach the inflation target by adjusting their spending. The findings could also motivate extensive government-funded expansion plans such as the American Green New Deal. Krugman (2009) speculates that the massive fiscal expansions attributed to the New Deal, especially WW2 fiscal expansion, were critical in ending the Great Depression. Krugman thus suggests that an extensive fiscal expansion could push the economy out of a growth recession. Krugman's (1999) speculations may already be a part of the reason for the recent record-high inflation in the EA and, to an even greater extent, in the case of the United States.

2. Theory and evidence

In order to meet the goals of this thesis, a theoretical framework is needed to explain why the effects of fiscal policy differ depending on the ZLB. An IS-LM model is used for this purpose. This chapter includes the main theoretical framework, previous research, and previous empirical evidence of the thesis. The chapter begins by briefly describing fiscal policy's implications and functions, followed by discussing previous research and empirical evidence on fiscal policy topics during periods of ZLB. The chapter will conclude by analyzing the consistency of the modified IS-LM model with reality.

2.1 Fiscal policy

Fiscal policy as a method of stimulating aggregated demand[2] during downturns originates in combating the adverse effects of the great depression and the economist John Maynard Keynes’s theories and subsequent book *General theory of employment interest and money*. Keynes proposed that a government can take action during recessions to mitigate adverse economic effects such as unemployment, bankruptcy, and uncertainty to lessen the consequences of a prolonged recession. Keynes theorized that the government could and should use its expenditures to raise aggregated demand to its normal level in downturns (Keynes, 1936). However, some economists disagree with Keynes's theory on aggregate demand.

There is a broad debate between the supply and demand sides in economics. Nobel laureate and economist Robert Mundell explained that in supply-side economics, it is understood that downturns are explained by problems in the supply of goods and can be fixed by decreasing taxes and deregulation, meaning that the government and central bank should take a more passive role in combating downturn. In contrast, demand-side economics describes a more active role of the government and central bank in recession combating (Krugman, 2013).

An outspoken supporter of demand-side economics, Paul Krugman (2009), explained that downturns could often be explained by temporary inadequate demand for goods and services, i.e., a fall in aggregate demand. In short, the low demand for goods can be explained by dismal future expectations, which leads to a "tightening of the belt" by both consumers and companies.

[2] Aggregated demand is the total demand of the economy. It can be thought of as the total demand of consumers, companies, and the government.

The "tightening of the belt" hence causes a fall in consumption and investment, further exacerbating the demand for goods. Demand siders, therefore, suggest that government can and should temporarily increase its spending to make up for the fall in demand. Likewise, the central bank can increase demand by expanding the money supply and making it cheaper to borrow money. In this thesis, I primarily use demand-side theory and measure how efficient the government's role in stimulating the economy is. Hence, the concept of aggregated demand is of utmost importance in this thesis.

A simple mathematical formulation of aggregated demand (Y^{ad}) is illustrated in equation 2.1 as an equation of consumption (C), investment (I), and government expenditure (G) (Blanchard, 2016, s. 73). In equation 2.1, consumption is a factor of the difference between income (Y) and taxes (T). Fiscal policy is defined as changes in (G), and (T). (G) contains government consumption and investment. If a recession causes a temporary reduction in © or (I), the government can theoretically retain aggregated demand on the same level by increasing (G) or decreasing (T).

$$Y^{ad} = C(Y - T) + I(Y, i) + G \tag{2.1}$$

Keynes suggested that governments use their consumption and investment to stimulate demand. However, this simple model for aggregated demand leaves much of fiscal policy's effects that need to be clarified. The relation between investments and fiscal policy is left ambiguous since fiscal policy has no direct effect on investment in the simple model in equation 2.1, but the investment is directly dependent on income (Y) (raises in (Y) should cause raises in (I)), the interest rate (i) may rise due to a fiscal policy which will lead to a reduction in investment. When fiscal policy reduces private investment and consumption, it is said to possess a Crowding out effect. Crowding out is when public action diminishes private incitements from the market (Spencer & Yohe, 1970).

2.2 Earlier researchers and empirical evidence

To contribute to the study of fiscal policy at the ZLB, a revision of the current literature is necessary. The most common method for analyzing fiscal policy at the ZLB is by using some variations of a New Keynesian model, such as Bouakez et al. (2017), Boubaker et al. (2018), and Swanson & Williams (2014). The strength of the New Keynesian model is its flexibility for different ways of application. Still, the models are criticized for relying on theoretical assumptions too much and not always being consistent with reality (Chari et al. 2009). There are, however, other ways to analyze the effects of the ZLB.

In recent years the VAR method has been gathering momentum in the analysis of ZLB. Some examples of different variants of vector autoregression (VAR) models are Bonam et al. (2022), Miyamoto et al. (2018), and Morita et al. (2018). The cause of the broader usage of the VAR method is the current influx of new data. The strengths and shortcomings of the VAR model are discussed more thoroughly in the method chapter. All the VAR studies mentioned in this thesis use different variations of the VAR model, indicating no consensus on which VAR model is the most suitable for analyzing ZLB.

Bonam et al. (2022) are among the first to use PVAR to analyze fiscal policy and ZLB. Bonam et al. (2022) also constructed a New Keynesian model and compared it to the PVAR model. As the other New Keynesian model, the Bonam et al. (2022) model multiplier is slightly larger than the PVAR multiplier. Miyamoto et al. (2018) use the Blanchard & Perotti (1999) SVAR model, which has served for a long time as the standard empiric model for analyzing fiscal policy. The model is, however, not suitable for this thesis since it can only be used on one country at a time. The differences between the empirical and theoretical models are notable, one is highly theoretical, and the other is entirely empirical. However, there is a strong tendency for larger fiscal multipliers when the economy enters ZLB in both approaches.

Taxes are an essential part of fiscal policy. The standard method for estimating SVAR models for a tax-based fiscal policy was developed by Blanchard & Perotti (1999). Blanchard & Perotti (1999) used knowledge of the elasticity of tax revenue to income to estimate the tax multiplier. This made it possible to estimate tax movement separated from changes in the GDP. Ramey (2019) ascertains that the estimated tax multipliers are sensitive to external tax elasticity. The problems with biases are prominent and are the reason why I do not estimate tax multipliers in this thesis since they require entirely different methods[3]

[3] The first alternative method is the natural experiment method, represented by Barro (1981). The second method is the narrative approach represented by Romer & Romer (2010). Both methods are feasible alternatives but do not fit this type of analysis well, and the methods have other biases.

Table 2.1: Table 1 is a summary of previous reaches of the subject.

Studies of fiscal policy in ZLB	The method used by the researcher	Fiscal multiplier in non-ZLB	Fiscal multiplier in ZLB	The country that was analyzed	The effect of ZLB on Crowding out	Fiscal policy's ability to brake counteract a liquidity trap
Swanson & Williams (2014)	New Keynesian model	< 1	>1	US	Less crowding out	-
Bonam, et al. (2022)	Panel VAR model	0.6	1.6	17 OECD countries	Crowding in	Can counteract a liquidity trap
Bouakez et al. (2017)	New Keynesian model	< 1	2.31	-	Crowding in	Can counteract a liquidity trap
Boubaker, et al. (2018)	New Keynesian DSGE model	1.1	1.8	FR, DE, IT, and ES	-	Can counteract a liquidity trap
Miyamoto, et al. (2018)	SVAR model	0.6	1.5	Japan	Crowding in	Can counteract a liquidity trap
Ramey and Zubairy (2018)	TVAR model	0.4	1.5	US	Crowding in	Can counteract a liquidity trap
Morita, et al. (2018)	TVP-VAR model	< 1	>1	Japan	Crowding in of consumption and crowding out of private investment	-

Table 2.1 consists of essential conclusions from previous research on fiscal policy at the ZLB. In all studies, the fiscal multiplier tends to be more prominent during ZLB. The fiscal multiplier is larger than one in all studies during ZLB. In regular times the multiplier tends to be somewhat smaller than one. Only Boubaker et al. (2018) estimate a multiplier more considerable than one in a non-ZLB period. The theoretical and empirical studies are unanimous in the conclusion that the fiscal multiplier is more prominent during periods of ZLB. However, there is a difference in the periods estimated and the chosen countries. The New Keynesian models enjoy more freedom regarding time frames and countries because of their theoretical nature. However, the VAR models are bound to the timer periods of the data and the selected country/countries. To better understand the difference between the sizes of the fiscal multiplier, one needs to analyze the effects in more detail. For example, Bonam et al. (2022) estimate government investment and consumption separately to identify the effects of different forms of fiscal policy in order to detect which has a more considerable impact.

The efficiency of fiscal policy can be examined by how the GDP components react. Some of GDP's components are total private investment and consumption. Miyamoto et al. (2018) and Bouakez et al. (2017) ascertain that there seems to be a more prominent crowding in effect of private consumption and investment in periods of ZLB. Miyamoto et al. (2018) argue that this is due to the lack of pressure on the interest rates during ZLB. Swanson & Williams (2014) stress that fiscal policy still causes crowding out of private investment in ZLB, but the effect is less considerable. Morita et al. (2018) determine that fiscal policy still crowds out private investment but crowds in private consumption. Bouakez et al. (2017), Boubaker et al. (2018), and Bonam et al. (2022) determine that significant enough fiscal innovations may cause an exit from ZLB. However, the exit was ascertained on a largely hypothetical level based on the assumption that the government expenditure should lead to future growth, which should, in turn, lead to inflation. Miyamoto et al. (2018) find no evidence that fiscal innovations can end a liquidity trap.

On the contrary, Miyamoto et al. (2018) conclude no apparent difference in how inflations react to fiscal policy in ZLB and non-ZLB periods. Bonam et al. (2022) find evidence that inflation increases more due to fiscal policy in the OECD countries during periods of ZLB. Higher inflation should lead to higher interest rates since banks and investors need higher returns to compensate for inflation, leading to an exit from the liquidity trap. However, there has yet to be a consensus on the liquidity trap-ending abilities of fiscal policy.

The issue of identification is a central theme of the method chapter. Ramey (2019) highlights the challenge of accurately estimating the fiscal multiplier using VAR models due to the difficulty of separating the cross-correlation between government spending and GDP to avoid bias. Government spending is a part of the GDP, so it is difficult to estimate and motivate a pure external government spending chock on the GDP. Blanchard & Perotti's (1999) non-recursive SVAR identification is the most common method for identifying fiscal chock. All the VAR models mentioned in earlier research papers except Ramey and Zubairy (2018) use some variation of the Blanchard & Perotti (1999) non-recursive SVAR identification. Ramey (2019) points out that in most cases, even with non-recursive identification, there may be bias in the estimates. The results may thus be guided by changes in the business cycle rather than genuine structural fiscal policy shocks.

In Ramey and Zubairy (2018), an essential question regarding estimating fiscal multipliers during periods of and without ZLB is whether the measured effects do to the state of the policy rate or if the multiplier is more affected by the state of the business cycle. Ramey & Zubairy (2018) find that multipliers tend to be more prominent during recessions, which adds to the need for further identification to estimate the causal effect of the ZLB.

2.3 IS-LM model analysis of fiscal policy with and without ZLB

The extant literature offers empirical support for a larger multiplier during ZLB periods. However, understanding the phenomenon requires explanation. This thesis introduces the notion of larger ZLB fiscal multipliers by employing an IS-LM model. The IS-LM model was developed by John Hicks (1937) as a formalization of Keynes's (1936) theoretical framework. An updated version is used in this thesis to make the IS relationship more realistic and usable for analyzing fiscal policy in the ZLB, which includes some endogenous expectations parameters (the endogenous expectations are added to make the model more forward-looking). Koenig (2011) uses an IS-LM model based on the Koenig (1993) modified IS-LM model to analyze the impact of ZLB in an IS-LM model framework. Koenig (2011, p 1) notes that endogenous expectations are vital to understanding why fiscal policy is more effective in times of ZLB.

Koenig (2011, p 2) ascertains that the LM relationship is reasonably sound, and its predictions match up reasonably well with reality. However, the IS relationship is more problematic since the expectation of the consumers is presumed to be exogenously fixed; however, this is quite unrealistic and limits the model's potential to accurately depict realistic scenarios. The consumer's future expectations primarily drive future consumption. By making the model's expectation endogenous, one can better estimate the actions of the consumers in downturns and the ZLB and incorporate the main theoretical assumptions from demand-side economics.

The model developed by Koenig (2011) depicts the equilibrium of a competitive economy with flexible wages and prices. By assuming rational expectations, the equilibrium rules the next period's expectations of the households. The utility-maximization of consumers, profit-maximization of the companies, and other equilibrium conditions are functions of linear logarithms. Some critical assumptions are that recreation and consumption must be normal goods[4], and the households utility function must be well defined between each period, consumption, recreation, and real money balances. Equation 2.2 is the firm production function where (Y) is output per capita, (N) represents labor-hours per capita, (β) is a fixed parameter assumed to be equal to or larger than zero and smaller than one, and (Θ) represents exogenous productivity that must be larger than zero. Equation 2.3 is derived by taking the logarithms of equation 2.2 where $y \equiv \ln(Y)$, $\theta \equiv \ln(\Theta)$, and $n \equiv \ln(N)$. The estimates for equation 2.3 are realistic for small (β) values. Profit maximizing firms are assumed to demand labor to the point where the marginal productivity equals the real wage, depicted in equation 2.4 where (w) and (p) are logarithms of the wage rate and price level. Equation 2.4 depicts a downward-sloping labor demand curve with a vertical intercept, and the slope of the curve is (- β).

$$\mathrm{Y} = \frac{\Theta N^{1-\beta}}{1-\beta} \tag{2.2}$$

$$y = \theta + (1-\beta)n - \ln(1-\beta) \approx \beta + \theta + (1-\beta)n \tag{2.3}$$

$$\theta - \beta n = w - p \tag{2.4}$$

The Household utility function is depicted in equation 2.5 where (C) is consumption, (σ) is the intertemporal elasticity of substitution, which is assumed to be larger than zero, and (λ) is a fixed parameter also assumed to be larger than zero. The marginal substitution rate between consumption and leisure for utility-maximizing households equals the real after-tax wage and is derived by taking the logarithm and then maximizing equation 2.5. Equation 2.6 is then driven by adding a predetermined tax rate on labor income (τ) (Koenig, 2011).

$$U(C,N) = \frac{C^{1-\frac{1}{\sigma}-1}}{1-\frac{1}{\sigma}} - \frac{N^{1-\lambda}}{1+\lambda} \tag{2.5}$$

$$\lambda n + \frac{c}{\sigma} = w - p + \ln(1-\tau) \approx w - p - \tau \tag{2.6}$$

Equation 2.7 depicts the resource constraint of the economy, where g is the fraction of output consumed by the government. By taking the logarithm of equation 2.7, one derives equation 2.8, where consumption is the difference between output and government expenditure. In the IS-LM model, (g) is considered an exogenous fiscal policy variable, and government expenditure per capita is proportional to output per capita. Government expenditure per capita

[4] Normal goods experience a demand increase when the consumers' income increases (Gravelle & Rees, 2004, p. 33).

depends on the economy-wide average output per capita. Thus, the labor-supply decision of the households has an insignificant effect on (G) (at least in the short run), where (g) is total government expenditure divided by the GDP ($g \equiv \frac{G}{Y}$).

$$\mathrm{C} = \mathrm{Y}(1 - \mathrm{g}) \tag{2.7}$$

$$\mathrm{c} = \mathrm{y} + \ln(1 - \mathrm{g}) \approx y - g \tag{2.8}$$

Koenig (2011) explains that by solving equations 2.3, 2.4, 2.6, and 2.8 for the equilibrium values for output, labor hours, consumption, the tax rate, the real wage as productivity functions, and the fraction of output consumed by the government, one derives the equilibrium equation 2.9-2.13.

$$y^* = \frac{(1 + \lambda)\theta + (1 - \beta)\frac{g}{\sigma} + (\beta + \lambda)\beta - (1 - \beta)\tau}{\Delta} \tag{2.9}$$

$$n^* = \frac{\left(1 - \frac{1}{\sigma}\right)\theta + \frac{g}{\sigma} - \frac{\beta}{\sigma} - \tau}{\Delta} \tag{2.10}$$

$$(w - p)^* = \frac{\left(\frac{1}{\sigma} + \lambda\right)\theta + \beta\frac{g}{\sigma} - \frac{\beta^2}{\sigma} + \beta\tau}{\Delta} \tag{2.11}$$

$$c^* = \frac{(1 + \lambda)\theta - (\beta + \lambda)g + (\beta + \lambda)\beta - (1 - \beta)\tau}{\Delta} \tag{2.12}$$

$$\Delta = \lambda + \beta + \frac{1 - \beta}{\sigma} > 0 \tag{2.13}$$

In the competitive equilibrium, consumption is decreased in both (g) and (τ). If one assumes in period (t) that consumers expect that markets will clear in (t + 1), then one can derive equation 2.14. The implication is that the IS curve responds by shifts to the right if consumers expects higher future productivity, smaller government spending as a share of output, or lower tax rates. With the model specifications specified, one construct is the IS-LM model.

$$\mathrm{E}c_{t+1} = Ec^*_{t+1} = \frac{E\left[(1 + \lambda)\theta_{t+1} - (\beta + \lambda)g_{t+1} + (\beta + \lambda)\beta - (1 - \beta)\tau_{t+1}\right]}{\Delta} \tag{2.14}$$

The investments savings curve (IS) depicts the relationship between investments and saving, often depicted as a line or a curve. The IS curve describes the equilibrium between the aggregated demand for goods and investment in the goods market. Assuming an economy without capital investment, the IS equation becomes a function of households' choice between current and future consumption given in equation 2.15 (Koenig, 2011). Capital investment is omitted to simplify the model. Capital investment is an important factor in the PVAR analysis but is of minor importance in the theoretical analysis. The propensity to invest is thus assumed to be a part of consumption. Consumers and investors thus face the options of whether to consume/invest or save their resources.

$$Ec_{t+1} - c_t = \sigma(r_t - \rho) \quad (2.15)$$

(r_t) stands for short-term real interest rate (which can be interpreted as the policy rate), (c_t) depicts the logarithm of current real consumption, (Ec_{t+1}) is expected consumption in the next period, (t+1) refers to de forward-looking expectations, and (ρ) and (σ) are fixed positive constants. The IS equation is derived by solving equation 2.15 for (r_t). Equation 2.16 depicts the relationship as an equation of (r_t).

$$r_t = \rho + \frac{Ec_{t+1} - c_t}{\sigma} \quad (2.16)$$

The incept of the IS curve is ($\rho + \frac{Ec_{t+1} - c_t}{\sigma}$), and the slope is given by (- $\frac{1}{\sigma}$). Equation 2.17 is derived from rewriting equation 2.16 as a relation between the nominal short-term interest rate (R_t) and, the future expected consumption and inflation. The rewriting results in the forward-looking nature of the model.

$$R_t = \rho + (Ep_{t+1} - p_t) + \frac{Ec_{t+1} - c_t}{\sigma} \quad (2.17)$$

(p_t) stands for the logarithm of the current price level, and (Ep_{t+1}) is the expected price level in the next period. Increases in (Ec_{t+1}) shift the IS curve horizontally. Assuming that (σ) is equal to one function 2.17 becomes function 2.18. The slope of the IS curve is now -1, and can only be shifted to the right if there is an increase in expected growth in nominal spending. Function 2.18 is only half of the model, and the LM equation needs to be derived (Koenig, 2011).

$$R_t = \rho + E(p_{t+1} + c_{t+1}) - (p_t + c_t) \quad (2.18)$$

The Liquidity preference-money supply (LM) curve captures that the velocity of money[5] increases in the opportunity cost of holding money. Blanchard (2016) explains that the LM curve is characterized by equilibriums between income and interest rates in which money supply equals money demand. Function 2.19 depicts the equation for money supply where (α) is the semi-elasticity of the nominal interest rate of the demand for cash, (p_t + c_t- αR_t) is the demand for cash, and (m_t) is the logarithm of the money supply. (p_t + c_t) is the logarithm of household expenditure. By rewriting equation 2.19 as an equation of the short-term nominal interest rate, one derives at equation 2.20. The equation for the LM curve is derived by maximizing equation 2.20 for the nominal interest rate and is depicted in equation 2.21. With both the IS and LM curves defined one can combine the curves in a graph that makes analysis easy.

$$p_t + c_t - \alpha R_t = m_t \tag{2.19}$$
$$p_t + c_t - m_t = \alpha R_t \tag{2.20}$$
$$R_t = \max\left\{ \frac{p_t + c_t - m_t}{\alpha} \right\} \tag{2.21}$$

The left-hand-side graph in figure 2.1 depicts the equilibrium state of the model. By assuming that prices are set one period in advance at a consistent market-clearing level equilibrium is derived (Koenig, 2011). The goods and financial markets are at equilibrium, with an equilibrium consumption level and an equilibrium interest rate. Figure 2.1 depicts the equilibrium when nominal interest rates are above the ZLB. The left-side graph in figure 2.1 shows that (R_t) coincides with the consumption level (c_t). The IS curve can be shifted to the right side by increasing the expected future consumption (this can be done with expansionary fiscal policy in some instances, derived from equation 2.17), as illustrated in the right-hand side graph where IS shifts to IS*. At the new level, both the consumption and the interest rate are higher at (c_t*) and (R_t*). Thus, the expansionary fiscal policy is dampened by a rise in (R_t), which has a contractive effect on consumption and, thereby, output. The increase in interest rates is said to crowd out private consumption. The model does not contain capital investments which are also assumed to be adversely affected by a rise in the interest rate similarly to consumption. The equilibrium function for output is depicted in equation 2.22, where (y) is the logarithm of the GDP and (g) is government expenditure as a percentage of the GDP. Equation 2.22 is a simplification of equation 2.1 depicted without investment.

[5] Wen & Arias (2014) define the velocity of money as measures the rate that money is exchanges in an economy.

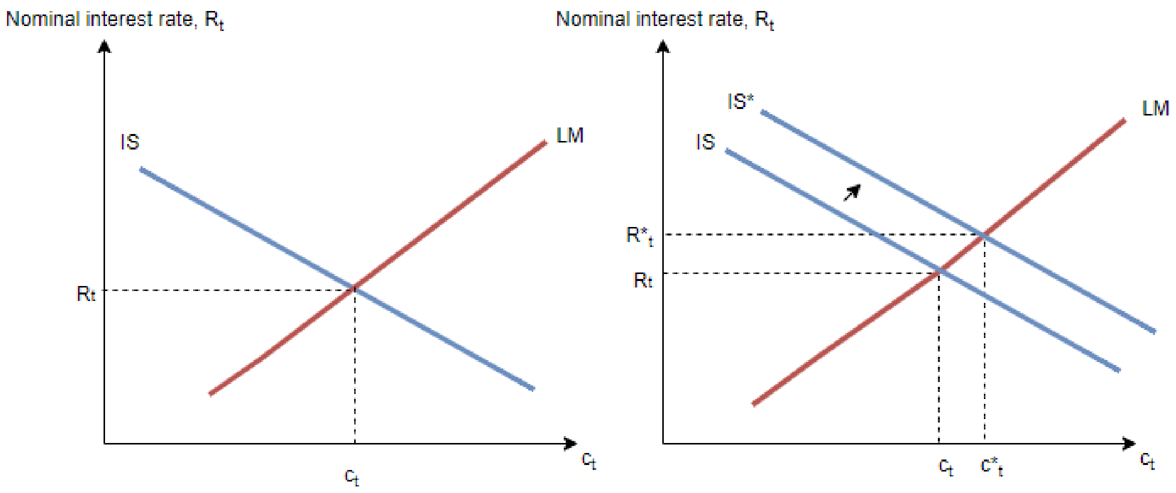

Figure 2.1: The IS-LM model relationship in periods' without ZLB.

$$y_t = c_t + g_t \tag{2.22}$$

The expansionary policy will increase public expenditure and output, but the fiscal multiplier is smaller due to an interest rate crowding out effect. Figure 2.2 depicts the same scenario but at the ZLB. In this scenario, a shift of the IS curve displays a more noticeable impact on consumption and, thus also, on output than in the previous scenario. There is no interest rate crowding out effect on consumption since there is no change in the money supply or demand. If the government now raises (g_t) by one percentage point of (y_t), it implies that the GDP increase is also one percentage. However, this conclusion only holds if the rise in (g_t) is implemented without changes in expected future tax rates or expected (g_t).

A rise in expected future taxes will contract expected future consumption, (Ec_{t+1}) (Koenig, 2011 p 12). The reduction of expected consumption will shift the IS curve to the left and offset some government efforts at stimulating the economy. The fiscal multiplier's size depends on whether the consumers expect the increase in (g_t) to be financed by future higher taxes. The size is also dependent on the longevity of the increase in (g_t). If the increase in (g_t) is not temporary it absorbs a larger part of (y_t) and diminishes consumption. The fiscal multiplier can be larger than one if the fiscal expansion does not increase the interest rate, and Ricardian equivalence is not binding. Ricardian equivalence is the phenomenon that implies that raises in present (g_t) has no marginal effect on consumption. Ricardian equivalence means that consumption does not increase, although government expenditure increases. If consumers expect future higher taxes, they will decrease their consumption in anticipation (Blanchard, 2016, p. 483).

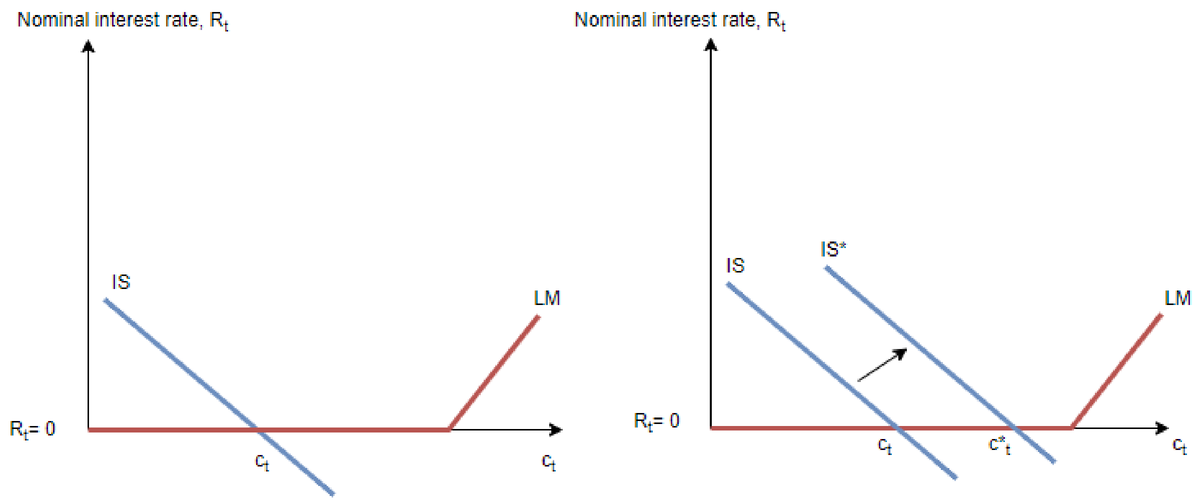

Figure 2.2: The IS-LM model relationship in periods' with ZLB.

As ascertained in the paragraphs above, consumer expectations are of utmost importance. Suppose the consumer expects that future decreases in (g_t) will compensate for the present increase in (g_t), with higher future (y_t) paying for the temporary increase in (g_t). The consumer ascertain that less future output is allocated to (g_t), increasing (Ec_{t+1}) by crowding in expected consumption, implying that the fiscal expansion will raise the GDP with the boost from (g_t) and (c_t). The increase in (g_t) and (c_t) is limited by the increase (r_t) under normal circumstances, but during periods of ZLB, the effects are amplified because of the horizontal LM curve. The expected consumption changes if fully reflected in current consumption and hence in output. Thus, the fiscal multiplier is more extensive than one if ZLB is binding. The larger fiscal multiplier during periods of ZLB seems to be in line with the empirical and theoretical evidence.

2.4 The consistency of the advanced IS-LM model assumptions with reality.

In the preceding subchapter, the foundational relationships of the IS-LM model were established. However, a more comprehensive analysis is necessary to fully explore the association between the interest rate, the anticipations of future consumption, and the velocity of money. The fundamental implication of the IS curve is that an increase in future consumption will push up the real short-term interest rates (r_t) if the economy is not in a liquidity trap (Koenig, 2011). One can conclude from equation 2.16 that if (Ec_{t+1}) increases, so does (r_t).

The opposite accrues if consumers expect bad times ahead, causing them to save their money instead of consuming it. Figure 2.3 illustrates the time series of (r_t) and the Consumer Confidence Index (CCI) for the entire EA. Both sequences are in the first difference. In figure 2.3, it is indicated that there is indeed a relationship between consumers' future expectations (future consumption) and (r_t).

When the consumers' future expectations fall, it leads to a slightly delayed fall in (r_t). When the consumer's future expectations improve, it causes a slightly delayed increase in (r_t). The relationship indicates that the main assumptions of the IS curve seem to fit quite well with reality. The sizes of the reactionary movements vary, but most notably, the trends seem weaker during times of ZLB. Both trends are less volatile during the pre-Cronoa pandemic ZLB period. During the Cronoa pandemic, there was a sharp decline in CCI, but relatively small reduction is observed in the (r_t), indicating the ZLB. However, the increase in CCI seemingly caused an increase in the interest rate in 2021, in line with the IS model predictions.

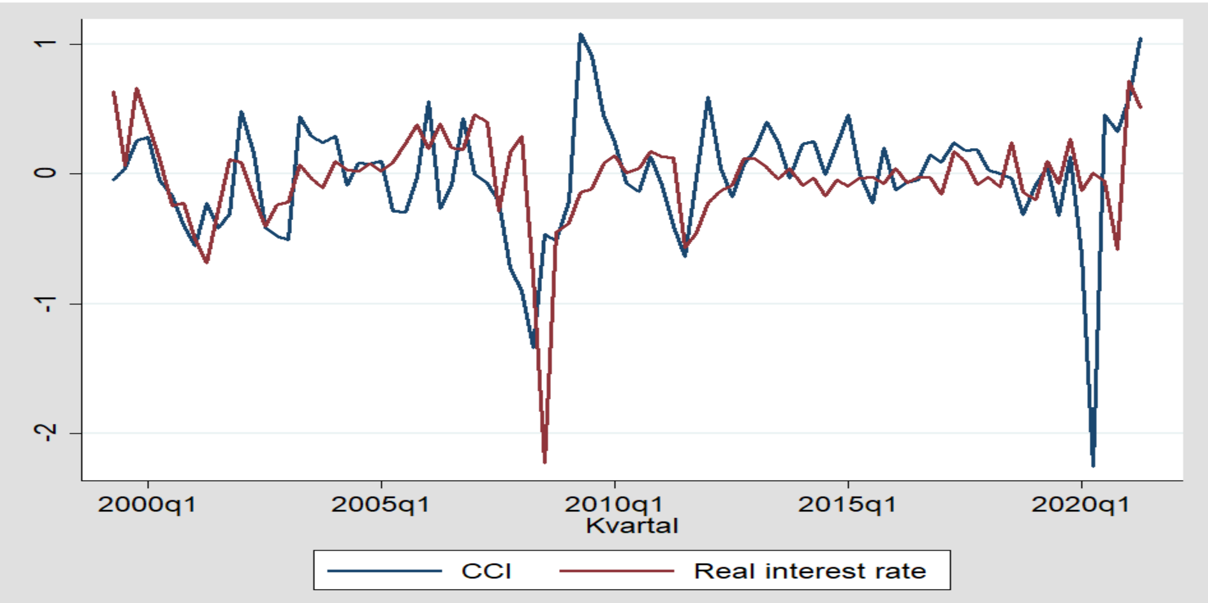

Figure 2.3: Real interest rate (r) and consumer confidence index (CCI), for the time period 1999-2021 for the EA.

Figure 2.4 depicts the relationship between the nominal interest rate (R_t) and the velocity of money, consistent with the first-difference version of equation 2.20. There also seems to be a co-movement between the variables in reality. When (R_t) increases, so does the velocity. When (R_t) falls, so does the velocity. The fall in (R_t) caused the velocity of money to collapse. In the wake of the financial crisis, the short-term interest levels fell to a negligible level, meaning consumers and investors are indifferent between holding cash or having it in a bank account. Leading up to the fall in (R_t) during the financial crisis, the velocity fell before (R_t), which might indicate a reversed relationship. After the ZLB, the co-movement has lacked somewhat due to ZLB. The velocity of money has since ZLB been slightly more volatile than (R_t), but overall, less volatile than before. During the Corona pandemic, there was a short but sizable collapse in the velocity of money. However, this can be explained by the restrictions, which temporarily decreased the velocity. The four-time series in Figures 2.4 and 2.5 indicate that the theoretical IS-LM model has some merit with reality, the IS relationships is especially strong.

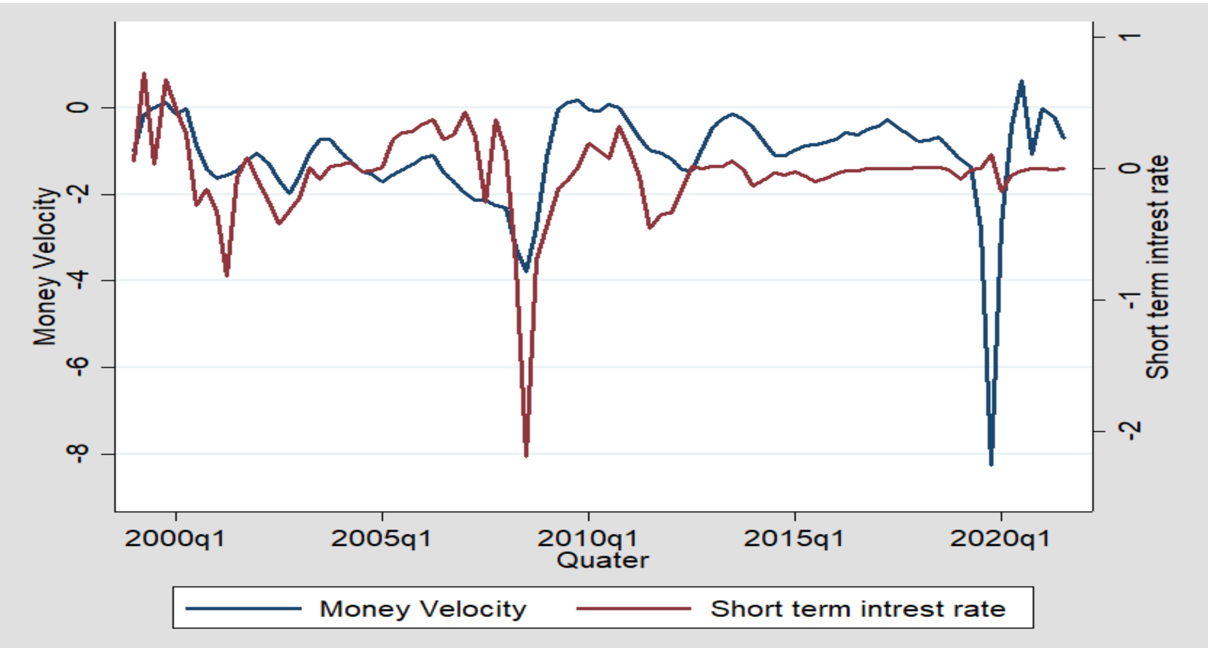

Figure 2.4: short term nominal interest rate (R) and the money velocity = real GPD / monetary base M2, for the time period 1999-2021 for the EA.

3. Data

Now that the fundamental relationships of the IS-LM model have been established with a certain degree of consistency, attention can be directed toward examining fiscal policy under the ZLB regime. To this end, an empirical model is essential for calculating the multipliers, and relevant data must be procured to inform this model. This chapter contains the variables used in this thesis and defines what constitutes a ZLB period. The choice of variables is based on theory and previous research. The discussion of ZLB is entirely based on observations made in the data and previous researchers. Some of the variables in the study are thus chosen because previous research on the subject recommends using the variable and in which specific form they could be used. The same variables in the same forms are used to make the thesis results comparable with the previous research. Other variables are chosen based on the theoretical assumptions made in the previous chapter; for example, CCI represents the consumers' future expectations.

3.1 A proxy for ZLB

ZLB has been a rare phenomenon in modern times, with the only exception being Japan, where ZLB has been present since the mid-1990s. Nevertheless, the policy rate in the EA has been below one and even zero after the financial crisis. ZLB was a mainstay in EA until recent times. To analyze the effects of ZLB on fiscal policy, one needs to define a reasonable proxy for ZLB. In Bonam et al. (2022), ZLB is identified as at least four consecutive quarters where the policy rate was below one. Ji & Xiao (2016) also recommend that the period of ZLB needs to be at least binding for 12 months to be legitimate. ZLB is identify as a period where the short-term nominal interest rate has been below 1% for four consecutive quarters. Figure 3.1 illustrates the development of the ECB policy rate.

In Figure 3.1, the red dashed line corresponds with a 1% policy rate. Before creating the euro in 1999, the policy rates between the countries tended to vary. When the original EA countries entered the monetary union, they gave up their control of the policy rate, and ECB harmonized the policy rate among them. The policy rate was temporarily below 1 in 2009 but not during four consecutive quarters and returned to a level above one for a few periods. The ECB: s sharp monetary response to the financial crisis is visible in figure 3.1, with a dramatic fall in the area's policy rate. Between 2012 and 2022, the policy rate was below 1% and negative between 2015 and 2022, meaning that ZLB is detected for eight years or 32 quarters. By dividing the period into two different periods, one can analyze the effect of ZLB. The first period is 1999-2012, where the average policy rate is 2.9%. The second period constitutes 2012-2022, with an average of - 0.1%, i.e., policy rate, well below the boundary of the proxy for ZLB.

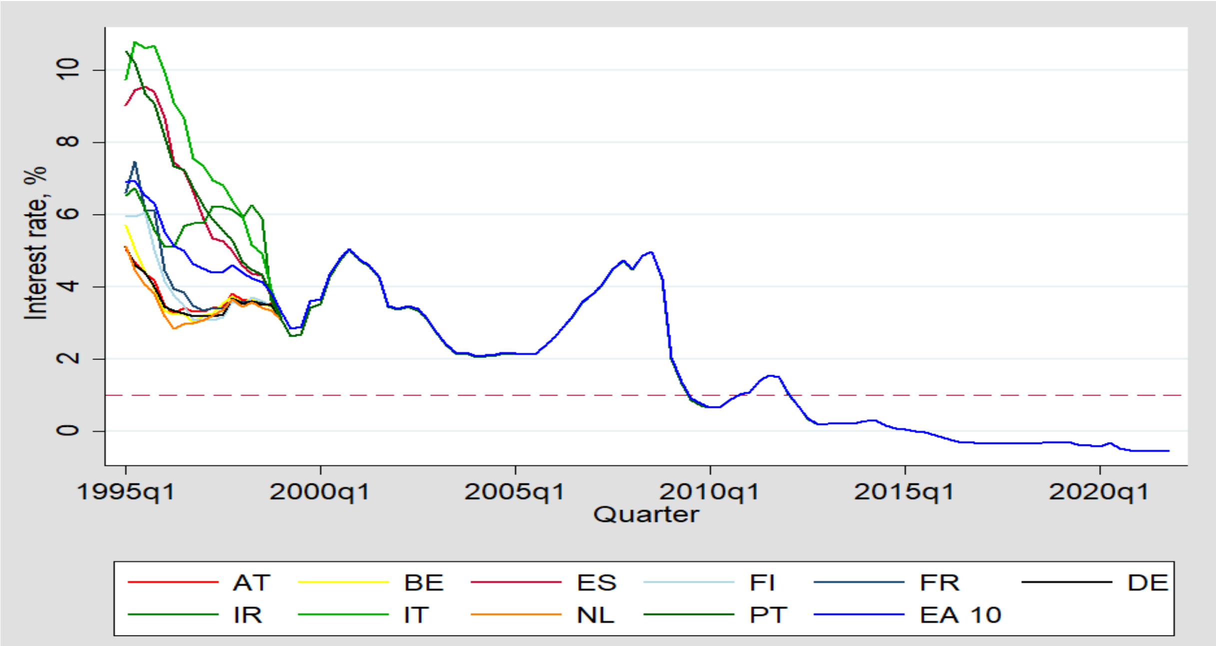

Figure 3.1: Short-term nominal interest rates for the original EA countries, 1995-2021.

3.2 The variables and data description

In this subchapter, all the data used in this thesis is presented. There is an emphasis on the data used in the PVAR. Table 3.1 depicts the data/variables that are used in the thesis. All variables are depicted in quarterly levels for the period 1999-2021. The data is gathered from OECD, ECB, and Eurostat. Some variables are aggregates for the entirety of the EA, and others are gathered separately for every member of the original EA countries.

The motivations behind the variables are the following. The short-term interest rate is used to identify the ZLB, the Consumer Confidence Index is used to analyze the consumer's future expectations, the Monetary supply M2 is used to illustrate the mechanics of the LM curve, the Harmonized Consumer price index (CPI) represents inflation, GDP is used in the PVAR module to estimate the multiplier, GDP deflator is used to convert GDP into terms of real GDP, Government consumption and investment are combined and represents total government expenditure, and the increase in the variable is measured on the rest of the variables, Private consumption and investment are used in the same manner as GDP.

Table 3.1: The variables included in the thesis.

Data:	Variable	Form:	Region:	Source:
Short-term interstate rate	ECB overnight lending rate	Depicted as actual period %	Original EA countries (1995-1999) and entire EA (1999-2021)	OECD
Long-term interstate rate on government bond	Interest rate on government bonds	Depicted as actual period %	Each Original EA separately	OECD
Consumer confidence index (CCI)	OECD gather CCI from consumers	Changes from one period to another	Each Original EA separately	OECD
Monetary supply M2	ECB estimate of total money supply[6]	The total amount in euros	Entire EA	European Central Bank(ECB)
Harmonized index of consumer price (HCPI)	Annual rate change of all items HICP[7]	Change from one period to another	Each Original EA separately	Eurostat
The GDP deflator	The real value of GDP	Change from one period to another	Each Original EA separately	Eurostat
The GDP	Gross domestic product at market prices	The total amount in euros	Each Original EA separately	Eurostat
Government consumption	General government final consumption expenditure[8]	The total amount in euros	Each Original EA separately	Eurostat
Government investment	General government gross fixed capital formation	The total amount in euros	Each Original EA separately	Eurostat
Private consumption	Final consumption expenditure of aggregated households	The total amount in euros	Each Original EA separately	Eurostat
Private investment	Private sector Gross fixed capital formation, Total fixed assets (gross)	The total amount in euros	Each Original EA separately	Eurostat

Table 3.2 is a collection of descriptive data used as variables in the model for the original EA countries, all variables are country-specific, and the PVAR analysis is conducted on the aggregated panel data. The variables are first depicted in their original forms. However, in the PVAR analysis, the variables Government consumption (Govt.con), Government investment (Govt.inv), Total government expenditure (Govt.tot), Private investment (Priv.inv), Private consumption (Privt.con) and GDP are depicted as logarithms, in their original form the variables are depicted in millions of euros. The logarithmical transformation is made to stabilize the PVAR model. Boneva, Braun, & Waki (2016) recommend the usage of logarithmical transformation because it reduces variations in the trends, variations in the error term, and non-linear relationships. The purpose of descriptive statistics is to give an overhead view of the model variables and to find differences between the periods.

[6] M2 money supply is the entire money supply in the EA. M2 is the sum of M1 (currency in circulation and overnight deposited) and deposits with a maturity of up to two years and redeemable deposited of up to three months. https://www.ecb.europa.eu/stats/money_credit_banking/monetary_aggregates/html/index.en.html
[7]HICP is the ECB created index for inflation and price stability. https://sdw.ecb.europa.eu/browse.do?node=9691135
[8] General government final consumption is the value of purchased and produced goods and services by the government. https://data.europa.eu/data/datasets/tleug5qxi7jd6dkpfzjvfw?locale=en

Table 3.2: Descriptive statistics of the model data						
Variables	Obesrvations	Mean	Standard deviation	Min	Max	Average change %
Non ZLB						
Govt.con	530	40556.72	38153.37	3198.28	129271	1.17
Govt.inv	530	6470.15	5722.74	691.38	21104.5	0.86
Govt.tot	530	47026.87	43586.43	3921.13	144834	1.11
GDP	530	201647.7	188789.7	21765.9	676229.3	0.90
Priv.inv	530	37454.99	34021.46	4881.68	123103.3	0.64
Priv.con	530	110965.1	106550.9	10086.5	370052.8	0.91
CCI	530	-0.08	0.59	-2.35	2.75	
Policy rate	530	2.85	1.31	.67	5.1	-.04
Inflation	530	2.17	1.23	-2.76	5.7	0.03
ln Govt.con	530	10.1	1.05	8.07	11.76	1.15
ln Govt.inv	530	8.31	0.99	6.53	9.95	0.65
ln Govt.tot	530	10.26	1.03	8.27	11.88	1.07
ln GDP	530	11.72	1.02	9.98	13.42	0.88
ln Priv.inv	530	10.07	0.99	8.50	11.72	0.61
ln Priv.con	530	11.09	1.06	9.21	12.82	0.90
ZLB						
Govt.con	390	54789.11	51322.27	7652.94	198130.5	0.63
Govt.inv	390	7175.32	6660.91	718.88	22824	0.83
Govt.tot	390	61964.43	57845.34	8553.76	220428	0.64
GDP	390	260304.2	240820.7	41699.2	874346.3	0.82
Priv.inv	390	47099.51	43606.11	5256.77	170695.5	1.15
Priv.con	390	139309.2	131204.8	19633.2	451289.8	0.36
Policy rate	390	-.13	.36	-.55	1.05	-.05
CCI	390	0.10	0.70	-4.13	3.05	
Inflation	390	1.13	1.01	-1.16	3.66	-0.01
ln Govt.con	390	10.43	1.02	8.94	12.19	0.63
ln Govt.inv	390	8.41	0.99	6.57	10.03	0.68
ln Govt.tot	390	10.55	1.02	9.05	12.30	0.64
ln GDP	390	12.02	0.96	10.63	13.68	0.76
ln Priv.inv	390	10.32	0.95	8.56	12.04	0.90
ln Priv.con	390	11.35	1.01	9.88	13.02	0.35

Table 3.2 depicts descriptive statistics for the aggregated EA. Table 3.2 is divided into actual values of the variables and the logarithmic versions of the cash variables, and this is done to depict variables in the form used in the analysis. Table 3.2 is divided into regular periods and periods of ZLB. Table 3.2 contains the number of observations for each period, the mean of the period, the standard deviation, the minimum and maximum values, and the average change in %. The standard deviation is used to analyze the volatility of the EA in different periods. A more notable number means that there has been more considerable volatility.

There are many observations in both periods (the observations are amounts of quarters in the periods). In the period without ZLB, there are 140 more observations; this will surely add to the accuracy of the estimate of the fiscal multipliers. The 390 observations should be enough to estimate the fiscal multiplier in times of ZLB. The changes in mean values depict that there has been a large change in size in all the monetary variables.

All monetary variables thus exhibit an upwards trend in their total size. The large differences can be seen in total GDP and government consumption. Government investment has also increased but to a lesser extent. The mean inflation and the policy rate are expectedly more substantial in the period without ZLB. The minimum and maximum values also depict the changes in size between the periods. However, the average change in policy rate depicts an important trend: interest rates in EA exhibited a downward rigidity since the conception of the monetary union.

Average changes % can be interpreted as the average GDP growth in the period. Notably, only the average growth in the GDP is similar in both periods. The growth in government expenditure is seemingly lagging behind the growth in output during the ZLB period. Before ZLB, the growth levels in government expenditure exuded that of output growth. The average growth in the interest rates during the ZLB period is negligible; it is expectedly negative. The standard deviation is seemingly larger for the monetary variables in periods of ZLB. The same can be ascertained about the interest rate and inflation. The variables are thus more volatile in periods of ZLB.

4. Econometric methodology

The objectives of the thesis can be achieved by verifying the assumptions of the IS-LM model. By leveraging the data from the preceding chapter, an empirical model can be constructed to assess the validity of the IS-LM model's assumptions regarding the larger multipliers under the ZLB regime. The estimations require the usage of PVAR and General Methods of Moment (GMM) instruments. The analysis of the fiscal multiplier is first spun into two-time frames, one with ZLB and one without. Conclusions about the effect of the ZLB on the efficiency of fiscal policy are made by analyzing differences in the size of the fiscal multiplier between the two periods. This chapter contains the thesis's primary empirical methodology. The choice of the empirical approach is based on the requirements needed to answer the thesis goals.

4.1 Vector autoregression (VAR) models

To understand how a PVAR model works, one first needs to understand the intuition of a VAR model. The VAR method was developed by Nobel laureate Christopher Sims (Kungliga vetenskapsakademin, 2011). Since its development, the VAR model has become a mainstay for empirical stochastic macro analytics. VAR models belong to the time series methodology and are a form of multiple-time-series analysis. Multiple meaning that one can analyze the relationship of multiple time series at once. VAR models are used, for prognostics, analysis of correlation and causality relationships, studying dynamic effects, and identification of structural shocks. VAR model coefficients are estimated as a linear function of historical values of variables and other variables in the model.

Equations 4.1 illustrates this thesis's benchmark VAR(p)[9] equations containing the constant intercepts v_i, the three variables government expenditure (G_t), GDP (Y_t), inflation (π_t) and their lagged values (Y_t, G_t, and π_{t-1}), the respective linear equation error terms (u_t^i), coefficients (c_n), the lags (p), and time (t). An estimate of (Y_t) is hence a linear function of historical values of (Y_t), historical values of (G_t), and (π_t), and an error term (u_t^Y). The estimates are a combination of historical values, correlation coefficients, and an error term. Estimation of a VAR requires further interpretations (Lütkepohl, 2005).

[9] A VAR (p) model symbolizes that (p) lags are chosen. The number of lags chosen is based on empirical selection criteria, which is discussed later.

$$G_t = \nu_1 + \sum_{p=1}^{l} c_{10}\, G_{t-p} + \sum_{p=1}^{l} c_{11}\, Y_{t-p} + \sum_{p=1}^{l} c_{12}\, \pi_{t-p} \;\; u_t^G$$
$$Y_t = \nu_2 + \sum_{p=1}^{l} c_{20}\, G_{t-p} + \sum_{p=1}^{l} c_{21}\, Y_{t-p} + \sum_{p=1}^{l} c_{22}\, \pi_{t-p} + u_t^Y \tag{4.1}$$
$$\pi_t = \nu_3 + \sum_{p=1}^{l} c_{30}\, G_{t-p} + \sum_{p=1}^{l} c_{31}\, Y_{t-p} + \sum_{p=1}^{l} c_{32}\, \pi_{t-p} + u_t^\pi$$

Equations 4.1: The benchmark VAR model contains government expenditure, output, and inflation.

Estimating a VAR model requires a rewriting the model into a more compact form that is easier to manipulate (Lütkepohl, 2005). Equation 4.2 depicts the VAR (p) model into its vector form. The different elements of the equations 4.1 are divided into separate vectors. There is an independent vector for the variable estimates, intercepts, lagged values of the variables, and error terms. The model coefficients are divided into a matrix multiplied by the lag term vector (Lütkepohl, 2005), the estimated coefficient is hence affected by the lagged values. Nevertheless, a further simplification of the VAR model is the reduced VAR model depicted in equation 4.3

$$\begin{bmatrix} G_t \\ Y_t \\ \pi_t \end{bmatrix} = \begin{bmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{bmatrix} + \begin{bmatrix} c_{10} & c_{11} & c_{12} \\ c_{20} & c_{21} & c_{22} \\ c_{30} & c_{31} & c_{32} \end{bmatrix} * \begin{bmatrix} G_{t-p} \\ Y_{t-p} \\ \pi_{t-p} \end{bmatrix} + \begin{bmatrix} u_t^G \\ u_t^Y \\ u_t^\pi \end{bmatrix} \tag{4.2}$$

The function of the reduced VAR model is to describe and manipulate the VAR model easily. (X_t) is a vector containing the model variables, (ν) is a vector of the constant intercepts, the matrix (C) contains the coefficients, (X_{t-p}) is a vector of the historical values, and (u_t) is a vector of the error terms. Hereafter all VAR models will be depicted in their reduced forms following the same logic as above. In the next paragraph, structural identification is introduced and explained.

$$X_t = \upsilon + \mathrm{C}X_{t-p} + u_t \tag{4.3}$$

4.2 Structural identification

Structural identification of fiscal shocks is needed to analyze fiscal policy's effects properly. In a VAR model, one assumes that the variables are independent. However, that is seldom the case between macroeconomic variables. There is a so-called identification problem with estimating a VAR model. The identification problem entails that a variable has a lagged effect on another and a direct effect in the same period (Koopmans, 1949, p. 125). Solving the identification problem entails retrieving underlying structural shocks. A structural shock is assumed to be an exogenous shock to the VAR system. Blanchard & Perotti (1999) assert that structural identification is thus needed to estimate the effects of a shock on one variable and its effects on the other. For example, in a VAR model with two variables, it is impossible to separate the impact of variable (x) on variable (y) from the effects of variable (y) on variable (x) (Lütkepohl, 2005). The identification complexity increases with the number of variables in the model.

Lütkepohl (2005) explains that recursive identification is used to identify structural shocks. Recursive identification was developed by Sims (1980 and 1989). In this study, the identification problem entails that fiscal variable (G) directly affects output (Y). However, the reversed relationship is probably genuine, as shocks in (Y) may also directly affect (G). Hence, it becomes impossible to measure causally (G's) effects when (G) is reacting to other variables in the system. Recursive identification works by applying Cholesky decomposition to solve the identification problem and recover the structural shocks. Recursive identification is part of a broader structural VAR (SVAR) methodology used to identify structural shock, often by theoretical restrictions on the variables' underlying relations. Blanchard & Perotti (1999) have developed a similar identification scheme to identify structural fiscal policy shocks. The structural identification of this thesis is a combination of Sims' recursive identification and Blanchard's & Perotti's semi-recursive identification.

Recursive identification implies restricting the correlation between the variable's error terms in the VAR model based on the order of the variables. Recursive identification implies that the ordering of the variables plays a crucial role in recovering structural shocks. The ordering of the variables needs to be supported by theoretical assumptions and intuition (Kungliga vetenskapsakademien, 2011). The effects are estimated on the assumption that a shock in variable (x) has a contemporary impact on itself, and variables (y) and (z) in the first period, variable (y) has contemporary effects on itself, and variable (z) in the first period, but not on (x), and variable (z) has no contemporary effects on the other variables.

Blanchard & Perotti (1999) argue that government expenditure should be placed first, followed by GDP, and then inflation, which means that fiscal policy has a contemporary effect on the other variables but not wise versa. This thesis implements recursive identification and Cholesky decomposition to identify the structural shock of fiscal policy on the other variables in the model. The ordering of the variables flows Blanchard's & Perotti's (1999) identification method.

Blanchard & Perotti (1999) ascertain that placing (G) first in the ordering is valid if the variable only contains government consumption and investment and is on a quarterly level. If these two requirements are met, one can assume that output (Y) has no immediate effect on (G). If changes in (Y) occur, it is assumed that it will take longer than one quarter for decision-makers to react and change government consumption and investment; the same conclusions are made in the IS-LM model. A shock in (G) can now be assumed to be exogenous in the first quarter. Inflation is believed to have no simultaneous effect on (G) or (Y), following conclusions from Bernanke et al. (1998). The following paragraphs give a more practical/mathematical definition of recursive ordering.

$$X_t = \beta_0 + \beta_1 X_{t-1} + \varepsilon_t \tag{4.4}$$

Equation 4.4 depicts the SVAR model where a recursive ordering is implemented (for a more detailed explanation of how to derive a SVAR model, see Appendix A). In short, the model is derived by adding a matrix A to the left side of equation 4.3 and then multiplying the model with the matrix inverse of matrix (A). (β_0), and (β_1) are derived by multiplying the vector υ and matrix (C) from equation 4.3 with the matrix inverse (A^{-1}). However, the important part is how the error term is structured. Equation 4.5 depicts the error term of the SVAR model as a linear function of the vectors contingent on the model's error terms multiplied by the inverse of matrix (A), containing the restrictions placed on the model.

$$\varepsilon_t = A^{-1} u_t \tag{4.5}$$

Lütkepohl (2005) concludes that recursive identification is made by restricting matrix (A) (for a more detailed mathematical construction of a SVAR model and the structural error term, see Appendix A). The right-side matrix in equation 4.6 portrays matrix (A) and the left side portraits the restricted version of matrix (A). The disparity between the quantity of unknown and known elements determines the minimal number of constraints necessary. Let (n) be the number of variables in the VAR. Matrix (A) has $(n^2 - n)$ unknown elements. There are also (n) unknown variances of (u^n), totaling: $(n^2$– n + n = $n^2)$. The estimation contains ((n^2 + n)/2) distinct known elements contained in the symmetric variance-covariance matrix of errors: $(E\varepsilon\varepsilon' = \sum\varepsilon)$. One can count known the number of known elements need, because there are (n) distinct elements from the diagonal, and ((n^2+ n)/2) elements off the diagonal. Since the matrix is symmetric the total number of known elements is: (n + (n^2 - n)/2 = (n^2+ n)/2). To summaries if one has a 3 variable SVAR model one needs to impose ((n^2 - n)/2) retractions, thus one needs 3 retractions in a 3-variable model ((3^2 -3)/2 = 3) (Sims, 1989).

$$\begin{bmatrix} 1 & a_{12} & a_{13} \\ a_{20} & 1 & a_{23} \\ a_{30} & a_{31} & 1 \end{bmatrix}, \quad \begin{bmatrix} 1 & 0 & 0 \\ a_{20} & 1 & 0 \\ a_{30} & a_{31} & 1 \end{bmatrix} \qquad (4.6)$$

Equation 4.6: Depicts matrix A and the recursively restricted version of matrix A

Equation 4.7 depicts the vector of the structural errors (u_t^n), for the tree variable SVAR model that is to be estimated. Equation 4.7 also depicts the final restricted vector of structural forecast errors (ε_t), which are linear combinations of the structural shock of (u_t^n). (ε_t) is derived by multiplying the reduced SVAR model with the inverse of matrix (A) (for more details, see appendix A).

$$\begin{bmatrix} \varepsilon_t^G \\ \varepsilon_t^Y \\ \varepsilon_t^\pi \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ -a_{20} & 1 & 0 \\ -a_{30} + a_{20}a_{31} & -a_{31} & 1 \end{bmatrix} \begin{bmatrix} u_t^G \\ u_t^Y \\ u_t^\pi \end{bmatrix} \qquad (4.7)$$

Equation 4.7: Depicts the structure of the error terms in vector form when recursive ordering is used.

The lower triangle of an invertible matrix containing the Cholesky factors. One must be aware that restrictions imposed on matrix (A) will affect the entire estimation. The inverse of matrix (A) is the Cholesky factor of ($\sum\varepsilon_t$). By imposing restrictions on the matrix (A) one can substitute ($\varepsilon_t = A^{-1}u_t$) into the variance-covariance (E$\varepsilon_t\varepsilon_t' = \sum\varepsilon_t$) to obtain (E($A^{-1}u_t\ u_t A^{-1\prime}$) $=\sum\varepsilon_t$) assuming that (E$u_t u_t'$ $=\sum u$ = I), one obtains (($A^{-1}IA^{-1}$) $=\sum\varepsilon_t$) which equals ($\sum\varepsilon_t(A^{-1}A^{-1})$), containing the recursive ordering (Blanchard and Perotti, 1999)

$$\varepsilon_t^G = u_t^G \tag{4.8}$$

$$\varepsilon_t^Y = -a_{20}u_t^G + u_t^y \tag{4.9}$$

$$\varepsilon_t^{\pi} = (-a_{30} + a_{20}a_{31})u_t^G - a_{31}u_t^y + u_t^{\pi} \tag{4.10}$$

Equations 4.8-4.10: Depicts the structure of the error term as liner functions when recursive ordering is used.

Equations 4.8-4.10 depicts the linear combinations of error terms for (G), (Y) and (π) which are the structural shocks to be estimated, in line with the Blanchard & Perotti (1999) model. The error term for government expenditure does now solely consist of the structural shock to government expenditure(u_t^G). The error term for output (ε_t^Y) is likewise a linear function of the coefficient (a_{20}) multiplied by the structural shock to (u_t^G) added by the structural shock in output (u_t^Y). The same is true for inflation. Note that the linear function for the structural error term increases in complexity with every variable added to the model. Because of the increasing complexity when variables are added it is essential to retain the model simple. In the next paragraph the PVAR model will be introduced. The PVAR model is the model that is used for the estimation of the fiscal multipliers in this thesis and uses both the recursive and the non-recursive identification form the SVAR model (Höppner, 2001).

4.3 Panel Vector autoregression (PVAR) model and GMM estimation

In the previous two chapters, the VAR and SVAR models were presented. By combining the two concepts, one can construct the PVAR model. PVAR with excluded country-fixed effects is utilized to estimate the impact of fiscal policy innovation on GDP and inflation in all estimated models. Holtz-Eakin et al. (1988) are the first to develop PVAR, and the model has since seen usage in both micro- and macroeconomics. The thesis PVAR model is constructed after Abrigo & Love's (2016) example. The advantages of using a PVAR model are numerous:

1. The PVAR model makes handling multiple variables and lags of the variables easy for analyzing dynamic relationships in the panel.
2. PVAR models are more efficient since aggregated data is used.
3. PVAR models can be estimated using both cross-sectional and temporal information, allowing for analysis of the causal relationships within the data.

4. PVAR models can solve endogeneity issues in the data by using instruments or accounting for fixed effects.
5. A PVAR model is estimated as a system of equations rather than multiple single equations.

Bonam et al. (2022) explain that the strength of the PVAR is that one can sufficiently analyze the aggregated effects of a phenomenon and thus minimize the risk of selection bias. A further strength of using PVAR is obtaining a more precise estimate if the available data has few observations. The PVAR model is used because the thesis aims to estimate an aggregated multiplier for the EA, not for any single country. A subsequent reason for the choice is that there are still relatively few observations of periods containing ZLB for the single EA countries. Even shorter periods are needed to analyze the validity of the benchmark model, which requires the flexibility that PVAR with GMM instruments offers. The estimation of PVAR requires further modifications to the reduced VAR model.

Equations 4.11 depicts the reduced PVAR model. Equation 4.11 is a k-variate homogeneous PVAR model with country-specific fixed effects. The main difference from the standard VAR model is that vectors are county-specific, denoted by (i) representing the vector-dependent variable-specific panel fixed-effects. (χ_{it}) is a (1 x k) vector of dependent variables, (A_{it}) is a (k x k) matrix of coefficients to be estimated. (ψ_{it}) is added as a (1 x L) vector of exogenous covariates and matrix (B) contains coefficients to be estimated. The main difference is the formulation of the error term. (a_i) and (e_{it}) are (1 x k) vectors of variable-specific panel fixed-effects and characteristic errors, meaning that country-specific dummy variables are created. The error term is split into two, with one constant part (fixed) and one part varying over time (Abrigo & Love, 2016). The constant factors can be described as climate, latitude, and the prevailing attitude toward fiscal policy. The exultation of the fixed effects should produce a more precise estimate (Murnane & Willet, 2010).

$$\chi_{it} = A_{it}\chi_{it-p} + B\psi_{it} + \mathrm{a}_i + \mathrm{e}_{it}\,, \\ \mathrm{i} \in \{1,2,\ldots,\mathrm{N}\}, \mathrm{t} \in \{1,2,\ldots,T_i\} \tag{4.11}$$

Abrigo & Love (2016) ascertain that parameters in equation 4.11 can be estimated jointly with fixed effects or separately of fixed effects using equation-by-equation ordinary least squares

(OLS). However, Nickell (1981) indicates that there is a considerable risk of asymptotic bias[10] when using fixed effects even with large (N), but biases approach zero as (T) increases. Abrigo & Love (2016) suggest using the generalized method of moments (GMM)[11] estimation to minimize bias.

The thesis uses GMM to create instrumented lagged variables because an equation-by-equation model is tedious, and the system model should yield better results. The instrumentation of the variables is also suitable because the main reasons for using instruments are already assumed. Namely, lagged values of the variables are expected to be able to explain future values of itself prominently. Ramey (2019) ascertains that SVAR models are pseudo-instrument variable models.

Abrigo & Love (2016) explain that if one assumes that error terms are serially uncorrelated, a first-difference transformation can be estimated as a system of equations by instrumenting lagged differences with differences and levels from previous periods. Roodman (2009) explains that the usage of GMM is suitable in the following cases:

1. Estimations with a small amount of (T) and a large amount of (N), meaning few periods and a large number of countries.
2. A function of linear relationships.
3. Variables that are dynamic, meaning that they depend on their historical values.
4. Independent variables that are not strictly exogenous. Rather, they are correlated with the error terms.
5. Fixed effects characterize the data.
6. There needs to be autocorrelation and heteroscedasticity within countries but not across them.

Abrigo & Love (2016) discuss that instruments can be utilized to address the endogeneity problem of employing PVAR models, which is, in fact, the same problem that Ramey (2019) ascertains plagues all VAR analyses of fiscal policy. Endogeneity occurs when the explanatory variables correlate with the error term, leading to biased estimates of the model parameters.

[10] Nickell defines asymptotic bias as bias caused by the upper limit of the maximum sample size.
[11] The first moment is simply the mean of a sample, the second moment is the variance and method of moments is the k.th moment of $E(x)^k$. GMM is a likelihood-based approach of estimating $E(x)^k$ (Hall, 2004).

Abrigo & Love (2016) suggest using instrumented lagged variables that are correlated with lagged endogenous variables but not the error term.

Lanne & Luoto (2021) find that it is indeed possible to indefinity structural shocks with GMM estimation. The function of instrumented lagged variables serves as instruments of the variables in the GMM estimator, allowing for consistent estimation of the PVAR model parameters. Instrumented lagged variables are thus helpful when the PVAR model has weak or endogenous explanatory variables. Thus, the usage of instruments is suitable for the study of fiscal policy.

However, there are a few problems with using GMM estimation. Firstly, the panels should be balanced. Secondly, the need for parameters increases with the chosen lag order. For example, a second order PVAR instrumented in levels needs a large number of lags $T_i \geq 5$ for each county in order to estimate the GMM equation. Roodman (2009) advocates that the model's efficiency is enhanced by including more lags as instruments. Holtz-Eakin et al. (1988) recommend that instead of equation-by-equation GMM estimation, one can estimate the PVAR model as a system of equations that result in efficiency gains. In practice, the difference between standard PVAR models and GMM estimation is that instead of using lagged values, one uses instruments based on lagged values.

Roodman (2009), Holtz-Eakin et al. (1988), and Abrigo & Love (2016) suggest that the Hansen J test[12] should be used to determine the number of lags that should needed when constructing the instruments when the model is overidentified[13]. An overidentified model should have the common set of (L > kp + l) instruments given by the row vector (Z_{it}), where $(\psi_{it}) \in (Z_{it})$. By transforming equation 4.11 into more compact form equation 4.12 is derived. Transformation of the variables are depicted by the asterisk.

$$
\begin{aligned}
\chi_{it}^{*} &= \mathrm{A}\widetilde{\chi_{it}^{*}} + \mathrm{e}_{it}^{*},\ \textit{Where:} \\
\chi_{it}^{*} &= \left[x_{it}^{1*}\ x_{it}^{2*} \dots x_{it}^{k-1*}\ x_{it}^{k*}\right] \\
\widetilde{\chi_{it}^{*}} &= \left[\chi_{it-1}^{1*}\ \chi_{it-2}^{*} \cdots \chi_{it-p+2}^{*}\ \chi_{it-p}^{*}\ \psi_{it}^{*}\right] \\
\mathrm{e}_{it}^{*} &= \left[\mathrm{e}_{it}^{1*}\ \mathrm{e}_{it}^{2*} \dots \mathrm{e}_{it}^{k-1*}\ \mathrm{e}_{it}^{k*}\right] \\
\mathrm{A}' &= \left[A_1'\ A_2' \dots A_{p-1}'\ A_p'\ \mathrm{B}'\right]
\end{aligned} \tag{4.12}
$$

[12] Hansen J test for the strength of the ability by testing for the exogeneity of the instrument (Roodman, 2009).
[13] Meaning that there are more instruments than actual parameters, whish is required in order to estimate GMM

The GMM estimator is constructed by tacking observations over panels and over time, depicted in equation 4.13 ($\widetilde{W}$) represents a weighted (L x L) matrix that is assumed to be non-singular, symmetric and positive semidefinite. The estimator uses a set of moment conditions derived from the theoretical model to estimate the parameters of the PVAR model. The GMM estimator aims to find parameters that minimize the difference between the sample moments and the theoretical moments. By assuming that (E(Z′ e) = 0) (instruments do not correlate with the error term) and rank (E($\widetilde{\chi_{it}^{*}}'$ Z) = kp + L) (the model needs to be overidentified), the GMM estimator is consistent. Hansen (1982) proclaims that ($\widetilde{W}$) should be selected in order to maximize efficiency. Abrigo & Love (2016) concludes that estimation of the entire systems of equations makes cross-equation hypothesis testing straightforward. To test the validity of the model a Ganger causality Wald test based on the GMM estimate of (A) and its covariance matrix can be conducted.

$$\mathrm{A} = \left(\widetilde{\chi^{*}}' \, \mathrm{Z} \, \widetilde{W} \, Z \, \widetilde{\chi^{*}}\right)^{-1} \left(\widetilde{\chi^{*}}' \, \mathrm{Z} \, \widetilde{W} \, Z' \, \chi^{*}\right) \tag{4.13}$$

4.4 Pre and post estimation

Before estimating a PVAR model, one must choose the optimal lag amount for the model and the instruments. There are many ways to determine the optimal lag amount. Among them are theoretical reasoning, intuition, examples from previous studies, and statistical information criteria. A few different information criteria are used to determine the optimal lag amount. Among them are Akaike's" information criterion" (AIC), Hannan and Quinn's "information criterion" (HQIC), and Schwartz's Bayesian's" information criterion" (SBIC). Information criteria are based on different statistical methods for prediction and tend to give different projections of the optimal lag amount. This thesis will use the three information criteria mentioned earlier to determine the optimal lag amount.

For PVAR lag selection Andrews & Lu (2001) propose the usage of moment and model selection criteria (MMSC), that are based on the Hansen J test. MMSCs are analogous to the maximum likelihood-based model selection criteria named above. By applying Andrews & Lu (2001) MMSC to the GMM estimator in equation 4.13 the proposed criteria can be described as vectors (q, p) that minimizes equations 4.14, 4.15 and 4.16. In equations 4.14-4.16 ($J_n(k, q, p)$) is defined as the J statistic for the k-variate PVAR of order (q) and the moment condition of (p) lags of the variables from the sample with size (n). The MMSCs ($\widetilde{W}$) can be maximized in accordance with Hansen (1982). When the optimal lag count is chosen, the model can be estimated. After the model is estimated, diagnostics are made on the model with Granger causality.

$$MMSC_{SBIC,n}(k,q,p) = J_n(k^2\,\mathrm{p}, k^2\,q) - (\,|\mathrm{q}| - \,|\mathrm{p}|)k^2 \ln(n) \tag{4.14}$$
$$MMSC_{AIC,n}(k,q,p) = J_n(k^2\,\mathrm{p}, k^2\,q) - 2k^2(\,|\mathrm{q}| - \,|\mathrm{p}|) \tag{4.15}$$
$$MMSC_{HQIC,n}(k,q,p) = J_n(k^2\,\mathrm{p}, k^2\,q) - Rk^2(\,|\mathrm{q}| - \,|\mathrm{p}|) \ln n\,,\ R > 2 \tag{4.16}$$

To estimate a VAR model, one needs to ensure that the model is stable. The first step to ensure stability requires that the variables are stationary. Stationarity implies that when there is a shock in a variable, it should only be a temporary departure from the series average (Lütkepohl, 2005). The implication entails that when there is a temporary shock in G, G should recover to the long-term average. If there is no recovery in G, it implies that the model is not stable (Lütkepohl, 2005, s. 25). To ensure the stationarity of the model, an augmented Dicky-Fuller test is implemented separately on the variables.

Dickey & Fuller (1979) developed the Dicky-Fuller test to measure stationarity. The Dicky-Fuller test controls for the null hypothesis that a unit root is present in the time series. The alternative hypothesis is that the time series is stationary or follows a so-called "random walk." Equation 4.17 depicts how an augmented Dicky-Fuller test is conducted on an autoregressive model (Enders, 2004). The model can be considered as a random walk if ($\varphi = 0$), and ($\gamma = 1$) and the statistical hypothesis testing can be considered as (H_0: $\gamma = 1$), and (H_1: $\gamma < 1$). To be able to estimate the model equation 4.17 needs to be subtracted by y_{t-1} on both sides, resulting in equation 4.18. By estimating ($\gamma - 1$), one can compare the resulting t-statistics and possibly reject the null hypothesis (Enders, 2004).

$$y_t = \varphi + \gamma y_{t-1} + \epsilon_t \tag{4.17}$$
$$\Delta y_t = \varphi + (\gamma - 1)y_{t-1} + \epsilon_t \tag{4.18}$$

As concluded in chapter three, government expenditure and GDP have a growth trend, meaning that they are not stationary in their original form. The standard in VAR and times series analysis is to estimate the variables in their first-difference form. Differencing entails that the change between two periods is used; this is done by subtracting a period's value from the previous period's value.

Table 4.1: Results from the Augmented Dicky-Fuller test Germany						
	Zeroth			First		
Variable	Test statistic	1% Critical Value	5% Critical Value	Test statistic	1% Critical Value	5% Critical Value
Govt.con	3.2	-3.525	-2.899	-9.901	-3.528	-2.9
Govt.inv	0.885	-3.525	-2.899	-9.822	-3.527	-2.9
Govt.tot	2.827	-3.525	-2.899	-8.251	-3.528	-2.9
Real GDP	0.205	-3.525	-2.899	-7.548	-3.527	-2.9
Priv.inv	0.031	-3.525	-2.899	-3.126	-3.527	-2.9
Priv.con	-0.758	-3.525	-2.899	-4.224	-3.527	-2.9
CCI	-	-	-	-6.861	-3.527	-2.9
CPI	-	-	-	-5.656	-3.527	-2.9
Interest rate	-0.399	-3.525	-2.899	-7.971	-3.527	-2.9

Table 4.1 exhibits the results from the augmented Dicky-Fuller test for the German variables. Unlike the other analysis of this thesis, the Dicky-Fuller test can not be conducted on the aggregated panel data. Instead, the Dicky-Fuller test will be done separately on the country's variables to ensure that the variables are stationary. The results of the other nine countries are available in Appendix B (tables B.1 – B.9). In table 4.1, all the variables that are used for the PVAR analysis are tested for stationarity. The first column depicts the variables, and the second column is a Dicky-Fuller test made on the variables in their zeroth difference (i.e., it is the original data in logarithmic form); the third column is the variables in the first difference. The variables can be considered stationary if the test statistic is smaller than the 1% or 5% critical value. All variables are stationary in the first difference. The same conclusions are drawn for all other countries meaning that all variables are estimated in their first difference. CCI and CPI are not tested in their original form since they are only used in their first difference.

The next step after the stationarity of the variables has been established, and the optimal lag amount has been decided is to ensure that the PVAR model is stable. The stability test is done by calculating all eigenvalues included in the model, and if all eigenvalues are smaller than one, the model can be considered stable. The model stability tests if a shock occurs. The shock should not spread indefinitely in the model. If it spreads indefinitely, it will cause the model to implode, meaning that the model may not use for estimation. If the model is stable, the model should converge back to the long-term trend after a shock has occurred.

Granger causality is used to determine whether the lagged values of the variables in the PVAR model are individually and jointly significant in predicting future values of another variable.

Lütkepohl (2005, s. 42) ascertains that granger causality assumes the cause can not come after the effect. The null hypothesis of the test is that all lagged values of a variable (x) display zero prediction power on variable (y), where all lagged values of (y) have been taken into account against the hypothesis that one or more lagged values of (x) improve the prediction of (y). If the latter hypothesis is true, (x) is said to Granger cause (y). However, in the model, there will be more than two variables.

Granger causality is merely a test of correlation, and does not imply causality (Lütkepohl, 2005 s. 45). Further identifications of the causal relationships between the variables are made with structural identification based on theoretical and practical assumptions. Not only will the lagged values of (x) and (y) be considered, but all the variables in the VAR model (Lütkepohl, 2005, s 41-45). For example, this study will measure Granger causality between government expenditure and GDP. The assumption is that government expenditure granger causes GDP. Granger causality can, however, not be interpreted as causality in the strictest sense. The Granger causality test also serves as a test of the feasibility of the GMM instruments. If Granger causality is present, it implies that the instruments are valid.

4.6 Impulse-response-function

The Impulse-response-function (IRF) is a central part of the thesis. It is used to analyze the effects of fiscal policy on the other variables via visualization. IRF results are used to estimate the size of the fiscal multiplier, and it functions as the primary tool for identifying structural shocks. IRF is used to simulate shocks based on underlying VAR estimation (Lütkepohl, 2008). By simulating shocks, one can analyze the dynamic effects between the separate variables in the model. For example, if a shock occurs in G, it will create surges in the other variables in the model and in itself. The shocks are made by implementing a one standard deviation shock in (G): s error term. The shocks in (G):s error term will affect the estimate of G and all the other variables in the system.

Structural identification and Cholesky decomposition are implemented to solve the identification problem. Structural identification and Cholesky decomposition can be implemented using the orthogonal impulse-response-function (OIRF). OIRF has the same function as IRF but solves the structural identification using the Cholesky decomposition discussed in part 4.2. Equations 4.8-4.10 illustrates the error term structure for the benchmark

PVAR model. When OIRF is implemented, the error term structure is that of the linear combinations depicted in Equations 4.8-4.10**.** A shock in (G) represents the structural chock in (G). A shock in (G) will affect all the other variables in the same period. Note that no other variables can affect (G) in the first period. (G) will still be affected by the other variables but only through the lagged values. To summarize, when a shock occurs in (G), it simultaneously affects the output, inflation, and interest rate. The values of the three lather variables will change. However, their changes will not affect (G). (G) is only affected by the changes in itself and the historical values of the other variables.

4.7 The fiscal multiplier

The fiscal multipliers are obtained through standardization of the OIRF results in line with Bonam et al. (2022). Equation 4.19 depicts the formulation of the fiscal multiplier. The results from the shock in GPD are transformed into real terms by dividing the cumulative sum from the OIRF with the GDP deflator and dividing it by the cumulative response of government expenditure. The transformation into the real GDP is made to account for the period's inflations. Periods of more considerable inflation thus negatively affect the multiplier size. A further transformation is that the response of government expenditure is multiplied by the average ratio between government expenditure and GDP. The average ratio is implemented to make the compression of the multiplier between the models and periods possible. The ratio transformation thus accounts for differences in the size of the spending. The size of the shock is thus measured in percentages of GDP. From 1999-2012, the avenger's share of government expenditure to GDP was 23%; from 2012-2021, it was 24%.

$$fiscal\ muliplier = \frac{\sum_{t=0}^{T} \Delta Y_t / Y_{deflator}}{\sum_{t=0}^{T} \Delta G_t * (G/Y)} \tag{4.19}$$

5. Results

In the preceding chapter, the methodological conclusions and the data gathering allow for an assessment of the accuracy of the IS-LM model's predictions regarding fiscal policy at the ZLB. If the results of the method concur with the theory, the main queries addressed in this thesis can be answered. This chapter comprises the estimation of the fiscal multiplier and the examination of the impacts of fiscal policy. The benchmark models are standard models for government expenditure shock, by standard meaning that it measures the effect of government expenditure on total output (GDP). Further aggregate demand analysis is required to conclude the relationships between aggregated demand and fiscal policy. The aggregate demand analysis is performed by developing four alternative models affirming or challenging the results obtained from the benchmark model.

5.1 The Benchmark models

The benchmark PVAR models constitute the three variables total government expenditure (G_{it}), output (Y_{it}), and inflation (π_{it}). The vector for estimation is thus $[G_{it}\ Y_{it}\ \pi_{it}\ ]$. The models are estimated in three different time frames, one for the entire period 1999-2021, one containing ZLB (2012-2020), and one without (1999-2012). The entire period model for the examination of the robustness of the two other models. There are, thus, three benchmark models with the same variables but with different time periods. A shock in G_{it} is simulated using OIRF in all models, and the effects are to be measured on output and inflation. The effects of the shock in (G_{it}) are then compared between the periods. The fiscal multiplier depicted in equation 4.11 is constructed for the benchmark model. Firstly, however, the number of lags in the models needs to be selected, and the stability of the models tested.

5.1.1 Modell specifications, Lag order selection, instrumentation and stability

In this subchapter, the model's instruments are created, lag specifications are chosen, and the stability of the model is tested. The lag specifications and choice of the number of lags used for the instrument are estimated simultaneously, as discussed in chapter 4.6. I use ten lags as instruments to maximize the number of lags used in the model. It is feasible to use up to ten lags in the PVAR estimation to maximize the usage of overall historical data. In order to fit ten lags in the GMM instrument, the model must be just identified or overidentified. Nickell's (1981) conclusion that the bias of the estimate is minimized also supports the choice of ten lags as an instrument. Following Bonam et al. (2022), the lag specification test is made on the entire period to not bias the choice of lags to any period. The drawback of choosing the lags on the entire period is that the number of lags chosen might not be optimal for ZLB and non-ZLB periods. Nevertheless, choosing the entire period is crucial to make the two periods comparable.

Table 5.1 depicts the results from the lag selection test. Whichever lag minimizes the MBIC, MAIC, and MQIC is the optimal number of lags. Four lags are chosen for the benchmark models based on Andrews & Lu's (2001) lag specification test depicted in table 5.1. However, the MBIC criteria recommend using a single lag model, but both the MAIC and MQIC recommend a four-lag model. The four-lag model is used for all models to make them more comparable. Models with a single lag will be estimated later to test the model's robustness. But the benchmark model thus contains instrumented variables based on ten lags, and the model will be estimated with four lags.

Table 5.1: Lag selection

lag	MBIC	MAIC	MQIC
1	-338.8599*	39.57482	-105.889
2	-319.5093	16.87705	-112.4241
3	-289.7896	4.54848	-108.59
4	-289.4393	-37.14951*	-134.1254*
5	-244.124	-33.88256	-114.695
6	-190.4264	-22.23317	-86.88374
7	-142.3305	-16.185	-64.67352
8	-98.43347	-14.33687	-46.66216
9	-47.2011	-5.152808	-21.31545

The circles in Figure 5.1 depicts all the model's eigenvalues. If one or more dots are outside the circle, the eigenvalues are above 1, and the model is unstable. The result depicts that both models display eigenvalues below 1, meaning that both models are stable. With the lag order selected, the instruments constructed, and the stability of the models tested, one can be pressed with the estimation of the PVAR model. After estimating the benchmark models, Granger causality can be implemented in order to determine the relationship between the variables.

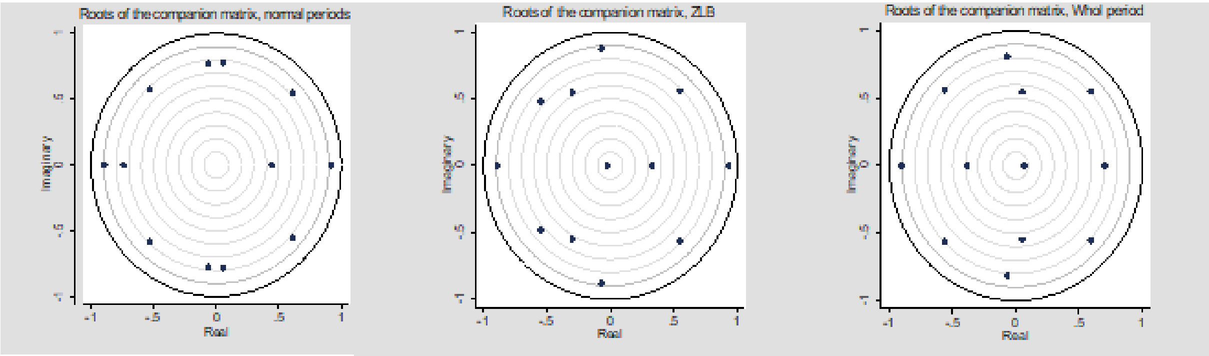

Figure 5.1: The roots of the comparison matrix, the result from the stability test.

5.1.2 PVAR estimation and Granger causality

Table 5.2 shows the result of the granger causality test of the three benchmark models. The upper part of table 5.2 is the results for regular periods, and the lower part is the result for ZLB periods. Chi2(1) and prob > chi2(1) are the models with and without ZLB. Chi2(2) and prob > chi2(2) represent the whole period model (1999-2020). The prediction power of the excluded variables is tested on the variable in the equation. For example, in the equation including output (Y_{it}), the predictive power of government expenditure (G_{it}) and inflation is tested.

The results indicate that the instruments work and can significantly be used to construct the fiscal multipliers. In all models (G_{it}), granger causes (Y_{it}). However, (Y_{it}) also granger causes (G_{it}) in all models except the whole period model. Noteworthy is that (G_{it}) also seems to granger cause inflation in most cases, except in the ZLB period model. In the case of the benchmark models, it is, however, expectedly concluded that (Y_{it}) also granger causes (G_{it}), so there is the risk of reversed causality. The usage of Cholesky decomposition and the usage of quarterly data should solve the problem, as discussed in chapter 3.4.

Table 5.2: Results from Granger causality test of the benchmark modles (1) The divided model (2) The whole period model						
Equation	Exluded	chi2(1)	chi2(2)	df	Prob > chi2(1)	Prob > chi2(2)
Non ZLB						
Total government expenditure (G)						
	Output (Yx)	72.794	1.525	4	0.000***	0.822
	Inflation (π)	12.345	8.124	4	0.015**	0.087*
	All	79.981	10.015	8	0.000***	0.264
Output (Y)						
	Expenditure (G)	9.423	20.867	4	0.051*	0.000***
	Inflation (π)	12.523	9.597	4	0.014**	0.048**
	All	32.349	26.456	8	0.000***	0.001**
Inflation (π)						
	Expenditure (G)	33.353	14.693	4	0.000***	0.005***
	Output (Yx)	28.750	11.645	4	0,000***	0.020**
	All	49.013	16.757	8	0.000***	0.001***
ZLB						
Total government expenditure (G)						
	Output (Y)	13.731	1.525	4	0.017***	0.822
	Inflation (π)	2.370	8.124	4	0.796	0.087*
	All	19.135	10.015	8	0.039**	0.264
Output (Y)						
	Expenditure (G)	22.754	20.867	4	0.000***	0.000***
	Inflation (π)	14.450	9.597	4	0,013**	0.048**
	All	33.476	26.456	8	0,000***	0.001**
Inflation (π)						
	Expenditure (G)	6.721	14.693	4	0.242	0.005***
	Output (Y)	23.100	11.645	4	0,000***	0.020**
	All	28.376	16.757	8	0.002***	0.001***
The statistical significance is denoted by ***, ** and * are 1 %, 5% and 10% -levles respectivly						

5.1.3 Impulse responses and the fiscal multiplier

The benchmark model multipliers are thus estimated with instruments and four lags; stationary variables, stable models, and the significance of the predictive power of government expenditure (G_{it}) on the other variables concluded. With all the earlier conclusions, the effects of structural shocks in government expenditure on output and inflation can be constructed using OIRF. The state of the variables implies that the OIRF graphs can be interpreted as growth or decline in the variables, for example, GDP growth or change in the inflation rate. In order to make it easier for the reader to follow along, the non-ZLB model is called benchmark (a), the model with ZLB benchmark (b), and the model for the whole period benchmark (c).

Figure 5.2 depicts the responses of the benchmark (a) model variables stemming from a one-standard-deviation shock in Government expenditure. The shock in (G_{it}) is sizable but mainly disappears after five quarters and becomes trivial. The expenditure returns to its regular growth rate with time. Output reacts immediately but weakly, and five quarters after the shock, it reaches its most prominent point and falls to negligible levels quickly. After 12 periods, it returns to its stationary state. Inflation has an initial deflationary response to fiscal policy, but after five quarters, that fiscal policy causes some inflation. The phenomena can be explained by a lagged response in inflation to fiscal policy. Inflation is not caused by the initial increase in government expenditure but by the aggregate increase in output after five periods. Further analysis of consumption, investment, and the consumer's future expectations is needed to explain the reaction of output and inflation in more detail.

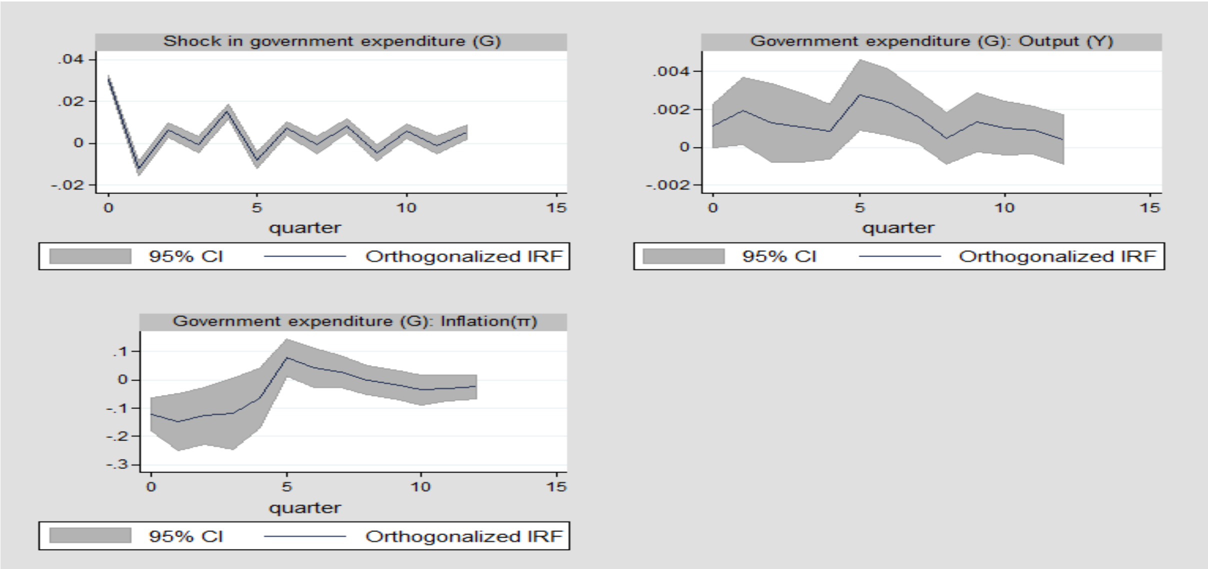

Figure 5.2: The IRF graphs that depict the responses of all variables to a shock in government expenditure for the period without ZLB

In many ways, the government expenditure and output response are similar in both models but differ critically. Figure 5.3 depicts the responses of benchmark (b) model variables stemming from a one-standard-deviation shock in Government expenditure. To make following along easier, benchmark (b) response analysis will compare benchmark (a) responses. The shock in (G_{it}) is initially more immense in benchmark (b), but the aggregated growth in government spending is more prominent in the period benchmark (a). The output effect is more extensive in benchmark (b) and lasts longer. The initial solid growth in output lasts for one year, then the effect declines and is inconsequential after two years. Notably, the output response confidence interval increases more with time, indicating that the longer-run effects are harder to determine.

As in benchmark (a), the initial response to prices is deflation. In contrast to benchmark (a), inflation rises faster and is 1% after three periods in benchmark (b), where it stubbornly stays until six quarters after the shock, then it begins its descent. After eight periods, the effect is negligible. As for benchmark (a), further investigation of consumption, investment, and the consumer's future expectations is required to explain the responses. Nonetheless, some patterns can already be detected when comparing the models. One is the difference in response to inflation and what can explain the difference. The response to inflation depends more on government expenditure's effects on output. The reasoning behind the conclusions is that in benchmark (b), output reacts faster and more robustly. However, the shock in (G_{it}) is similar in size and duration in both models, indicating that (G_{it}) does not cause much inflation. The conclusions are further supported by the fact that output granger causes inflation in every model.

The more robust output response in benchmark (b) does not necessarily mean that the multiplier is larger since one can not draw clear conclusions only from the figures. Thus, the next step is the construction of the multipliers.

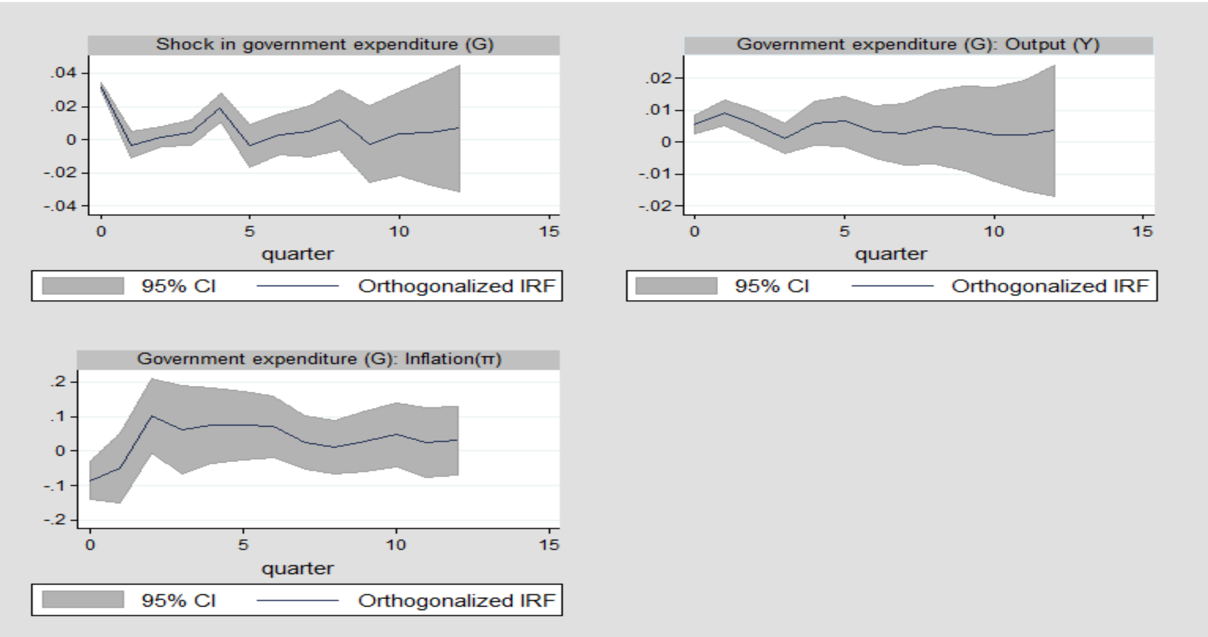

Figure 5.3: The IRF graphs that depict the responses of all variables to a shock in government expenditure for the period with ZLB

Figure 5.4 depicts the cumulative fiscal multipliers of all three models derived from the OIRF: s graphs. As previously noted, benchmark (c) is added to compare the two other models to the entire period. It can be thought of as an assessment of the robustness of the multipliers. Logically the whole period multipliers should be somewhere between the two other models since it is derived from both periods. If the responses in benchmark (c) are not a combination of the benchmark (a) and (b), the results of (a) and (b) might be caused by bias in the model and not dependent on the different periods. The impulse response graphs of the whole period model are illustrated in figure B.1 in Appendix B.

Initially, benchmarks (b) and (c) exhibit a similar base point, and benchmark (a):s base point is lower. The benchmark (a) multiplier increases slowly, reaching a peak of 0.43 eleven quarters after the initial shock, and its decline follows. The fiscal multiplier never exceeds 0.5 and averages 0.3 for the entire period. The initial response of benchmark (b) is four times larger than benchmark (a). There is a substantial increase in the size multiplier for benchmark (b) between quarters 0 and 3. The growth slows down and essentially stops. The benchmark (b) multiplier reaches a peak of 1.85 ten quarters after the initial shock, averaging 1,52 for the whole period. Benchmark (c) development is relatively similar to benchmark (b) but far less powerful. The multiplier reaches its high point of 0.93 four quarters after the shock and stays on a similar level for the entire period.

Benchmark (c) indicates that there is indeed a difference in the multipliers caused by the different periods. The benchmark models conclude that the fiscal multiplier is more considerable in periods of ZLB, supporting the IS-LM model and Keynesian theory. The previous research with similar conclusions and sizes of the multipliers further supports the results. In conclusion, when the government spends 1 unit, it results in an aggregated output increase of 1.52 in periods of ZLB and an increase of 0.3 in periods without. In summary, the EA fiscal multiplier has averaged 0.9 between 1999 and 2020. In the first half of the EA existence, it was 0.3, and in the second half 1.52.

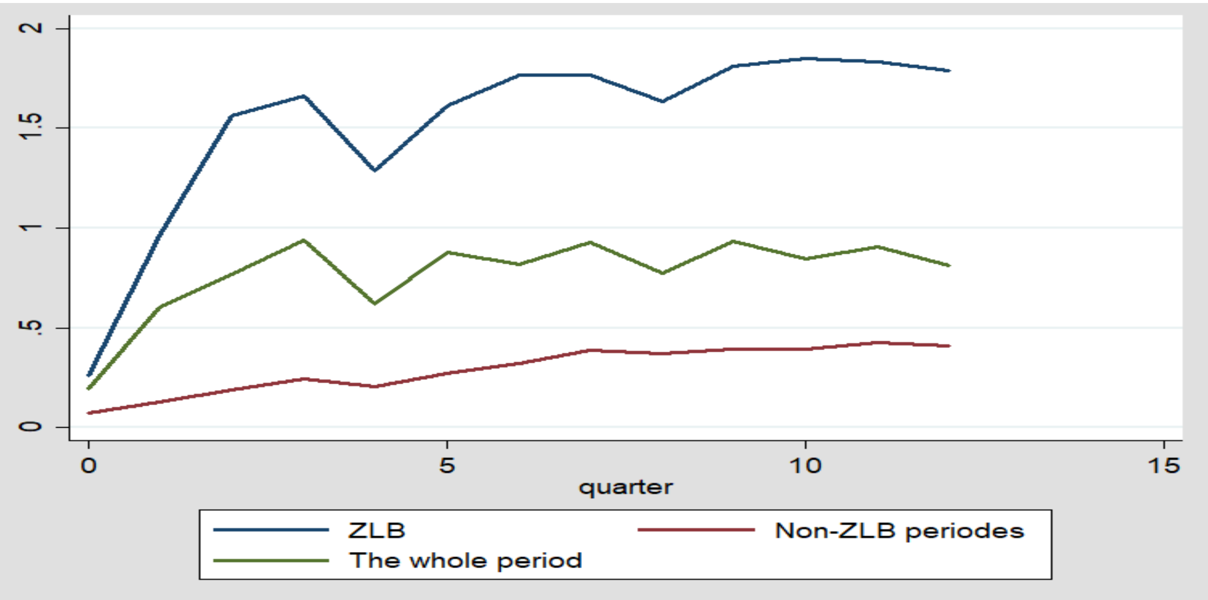

Figure 5.4: The fiscal multiplier for the three benchmark models (the aggregated response in GDP related to the aggregated response in total government expenditure of a shock in government expenditure, as depicted in equation 4.19)

The remainder of the analysis consists of a deep dive into why the responses in output differ between the periods and can be explained by consumption, investment, and the consumer's future expectations, i.e., change in aggregated demand.

5.2 The alternative models

The alternative models are composed of four different models used partly to deepen the analysis of the market reaction, control for biases generated by measuring the effects on o GDP and analyze fiscal policy effects on the consumer's future expectations. In the first alternative model, called the private output model, GDP is redefined as the sum of privet sector consumption and investment that quarter. A further change to the model is exchanging GDP with private consumption and investment and CCI to strengthen the benchmark model result and analyze the consumer's future expectations[14]. The robustness of benchmark multipliers is thus tested in various ways. To make the alternative models more comparable with the benchmark models. The same number of lags for the model and the instrument is used.

5.2.1 The private output model

In the private output model, there are three scenarios: one for ZLB periods, a second for non-ZLB periods, and a final model for the entire period. The estimate model vector can now be described as$[G_{ti}\ Yx_{ti}\ \pi_{ti}\ ]$, where Yx_{it} is private output. The redefinition of GDP has a dual purpose. Firstly, it allows for a deeper analysis of how the private sector reacts to government expenditure. Secondly, it excludes the reverse causality bias since government expenditure can more easily be assumed to be an exogenous factor to the redefined GDP variable. Government expenditure is more exogenous to private consumption and investment than GDP. As for the benchmark models, the multipliers are constructed from the OIRF responses to government expenditure and the private output variable (the OIRF graphs are depicted in figures B4-B6 in Appendix B, the models are also deemed to be stable, see figure B2 in Appendix B).

The final model multipliers are depicted in figure 5.5. The only difference is that impulse in government expenditure is multiplied by the average ratio between government expenditure and total private consumption and investment. The size of the shock is thus measured as a

[14] All three models are estimated separately, i.e., one for private consumption, one for private investment, and one for CCI.

percentage of changes in total private consumption and investment. As the benchmark models, all the private output models use GMM instruments made of ten lags of the variable. All three models are stable (see figure B.2 appendix B). Inflation is a part of the model but will not be examined separately as the benchmark models' inflation response is the final version. Inflation is left in the models to make them more comparable to benchmark models.

Figure 5.5 illustrates the new multipliers for the three scenarios. The response in the model with ZLB is very similar to that of the benchmark model, with the only difference being that there is a more gradual increase in the multipliers sizes. The ZLB multiplier is somewhat weaker, with peaks of 1.48 and an average of 1.01, which is to be expected since government expenditure is no longer directly a part of the output. Meaning that the increase in government expenditure is not directly measured in the redefined output variable.

As in the benchmark model, the multiplier peeks after ten quarters, stabilizes, and begins to decent. However, the non-ZLB period multiplier is somewhat different from the benchmark model. Firstly, it is negative for the first two periods, indicating crowding out or the effect of government expenditure is lagged. Secondly, it is smaller than the benchmark model, with a peak of 0.20 and an average of 0.10. The lagged effect on output seemingly indicates that in non-ZLB periods it takes a couple of periods for the private sector to react. The whole period model multiplier is similar to the benchmark model but somewhat smaller.

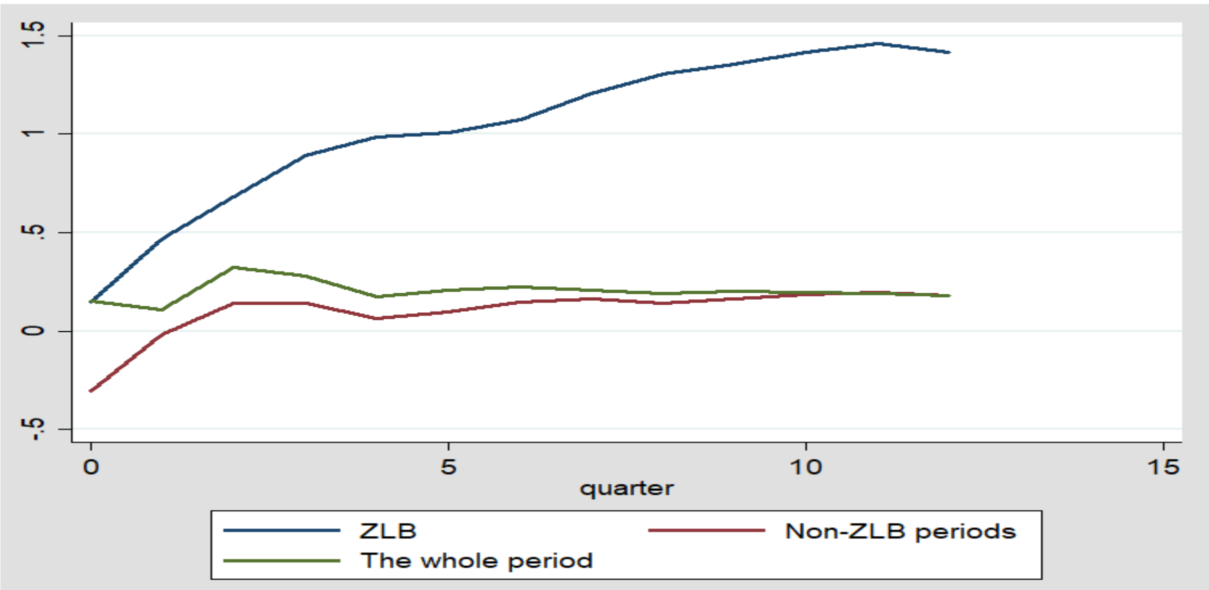

Figure 5.5: The Fiscal multiplier for the three private output models (the aggregated response in Yx_t related to the aggregated response in government expenditure of a shock in total government expenditure, as depicted in equation 4.19)

How consumers and investors react to expansionary fiscal policy plays a critical role in the size of the multiplier. The sizes of the fiscal shocks are similar in both the benchmark and private output models. However, the non-ZLB period model's reaction differs from the benchmark model. Since government expenditure is not directly a part of private output, it only has a secondhand effect on the variables.

The weaker response of the benchmark non-ZLB period multipliers can be explained by a weaker response in privet sector activity which is in line with the theoretical framework of the IS-LM model. In non-ZLB periods in the IS-LM model, the output growth is only generated by increased government expenditure. The small multipliers in non-ZLB periods support the IS-LM model assumption that expansive fiscal policy has a smaller multiplier when the economy is at the ZLB. The strong reaction of private output in periods of ZLB and the weak private output reaction in non-ZLB periods has some explanatory power of why the benchmark multipliers differ between the periods.

5.2.2 The consumption and investment models

The consumption and investment models are used to analyze the privet sector's response to fiscal policy thoroughly. The consumption model analyzes the response of the total private sector consumption to fiscal policy and thus advances the conclusions from the private sector model. The estimated PVAR model is $[G_{ti}\ PC_{ti}\ \pi_{ti}]$, where PC_{ti} represents private consumption. Measurements are made for periods of ZLB and non-ZLB periods. The whole period effects are not measured. The multipliers are constructed from the OIRF responses to government expenditure and private consumption. The only difference is that the shock size is thus measured as a present change in private consumption and investment instead of output.

The investment model is the same as the consumption model. The only difference is that private consumption is changed to private investment, and the estimated model is hence $[G_{ti}\ \ PI_{ti}\ \ \pi_{ti}]$, where PI_{ti} represents a private investment. There are two reasons for not estimating a single model containing private consumption and investment as separate variables. The first reason is to avoid large models since it lessens accuracy. The second and more important reason is that ordering the variables in an OIRF is of utmost importance, as explained in the methodology chapter, since ordering the variables requires strong assumptions of the causal relationship between the variables, which is not feasible. The OIRF graphs of the consumption and investment models are depicted in figures B7-B10 in Appendix B). All models are stable and may be estimated (see figure B.3 appendix B).

Figure 5.6 illustrates the multipliers for the two models and periods. The trend in the development of consumption after the shock is similar between the periods. However, the response of private consumption is expectedly more enormous in periods of ZLB, with a peak multiplier of 0.47 compared to a multiplier of 0.27 for non-ZLB periods. The average multiplier of periods of ZLB is 0.35, and the average for non-ZLB periods is 0.19. The fiscal policy thus has more impact on consumption in periods of ZLB. However, the difference is less important than the whole economy multiplier between the periods. The slight difference between the periods alludes that consumers prefer fiscal policy at the ZLB, but the difference is less than for the economy as a whole. Following that, something else most explains the multipliers' size differences in the two benchmark models rather than the consumers' reaction.

In figure 5.6, the investments multiplier is also illustrated for both periods. In contrast to the consumption multiplier, the difference between the periods is extensive. For periods of ZLB, the impact multiplier is 0.27. The multiplier grows until the tent quarter reaches a peak of 0.74 and then begins declining. For non-ZLB periods, the impact multiplier is zero, and then it becomes negative until the sixth quarter, when it returns to its long-run trend. A comparison of the average multiplier shows that ZLB averages 0.64 and the non-ZLB period multiplier averages -0.015. The conclusion is that in periods of ZLB, there is crowding in of private investment, and in non-ZLB periods where fiscal expansion has no effect or crowding out effect on private investment.

The analysis of private consumption and investment concludes that there is a clear difference between the effects of fiscal policy between ZLB and non-ZLB periods, with a large multiplier in ZLB periods. There is a slightly larger consumption multiplier during periods of ZLB. The difference is, however, not enough to explain the difference between the sizes of the benchmark multipliers. Nevertheless, the differences in the investment multiplier between the periods are considerable and can largely explain the differences in the benchmark multipliers. So, the multiplier's size largely depends on how the aggregated investment and investors react to the fiscal stimulus.

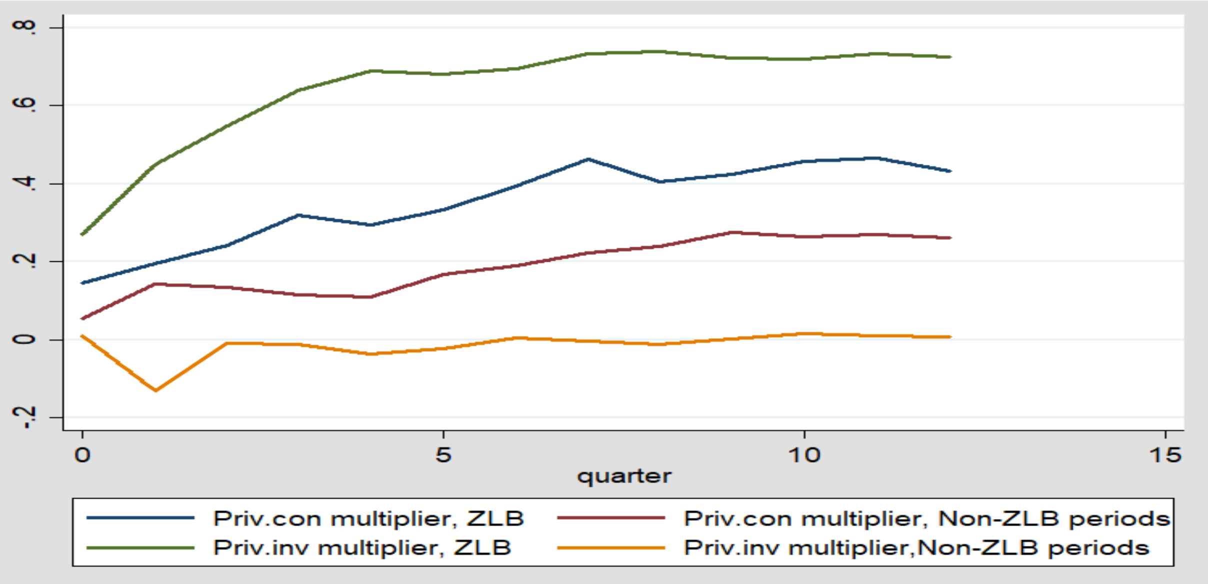

Figure 5.6: The private consumption and investment multiplier for ZLB and non-ZLB periods.

5.2.2 CCI model

The fourth and last alternative model analyzes how the consumer's future expectations react to fiscal policy in ZLB and regular periods. As in the previous three models, there is a new version of the PVAR model with the CCI replacing the output. The model is hence $[G_{ti}\ CCI_{ti}\ \pi_{ti}]$. In contrast to all other models of the thesis, multipliers will not be constructed to analyze the consumer's future expectations. The reasoning for not constructing a multiplier for CCI is that the nature of an index makes the interpretation of the multiplier unclear and unnecessary for analyzing future expectations. The models are stable and may be estimated (see figure B.3 appendix B)

Figure 5.7 depicts the reactions of CCI to shock in government expenditure. In both periods, the initial reaction is close to zero. However, one quarter after the shock, there is a rise in CCI, indicating that it takes consumers one quarter to react to the fiscal expansion. In both periods, there is an increase in CCI in the first quarter, but the increase in periods of ZLB is twice as large. The reaction to CCI is, however, short-lived. In regular periods the rise in CCI last only for three quarters, and then the growth largely disappears. The reaction of CCI in periods of ZLB is slightly longer lived, with a strong initial reaction that lasts five quarters, after which the effects largely disappear. The short-lived reaction combines with the results from the consumption multiplier; however, indelicate that the effects are somewhat limited. The conclusion is that fiscal expansion raises consumers' future expectations per the IS-LM model assumption.

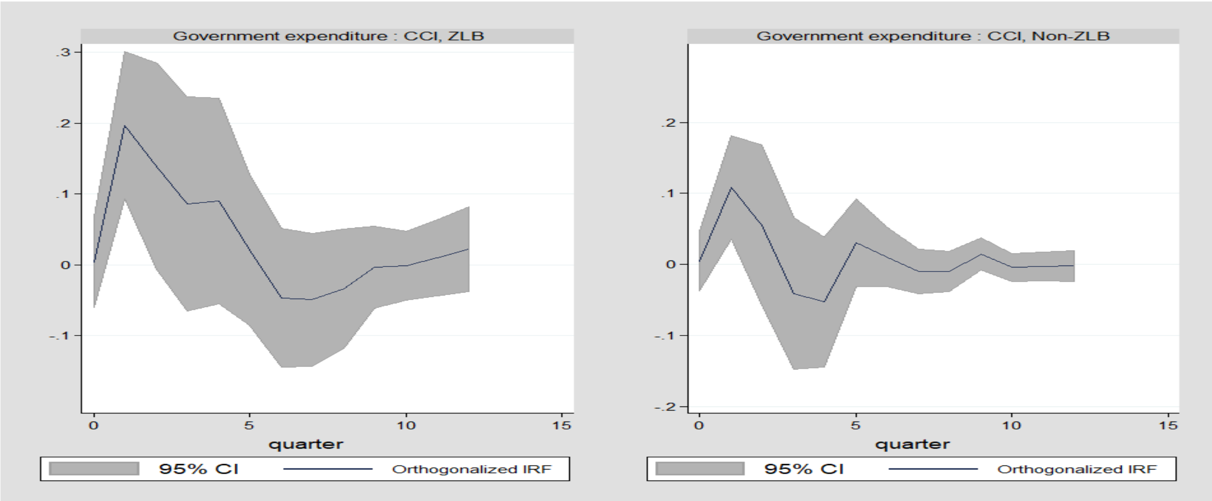

Figure 5.7: Response of CCI from a shock in government expenditure in periods of ZLB and non-ZLB periods. OIRF graphs.

5.2.3 Granger causality analysis of the alternative models

Table 5.3 depicts the results of the granger causality tests for all alternative models. The effects of inflation are omitted because it is not of interest in the alternative models. Table 5.3 is divided into three parts: whole period, non-ZLB, and ZLB. On the left-hand side, the granger causality of government expenditure on the variables of interest is measured, and vice versa on the right-hand side. The result for the private output model indicates that there is indeed a strong relationship between private consumption and investment and government expenditure in all models and periods. However, there is still a strongly reversed casualization between the variables.

Table 5.3 Results from Granger cauality test aletnative model 1-4

Whole period	Equation	p-value		Equation	p-value
Govt.exp (G)	Output(Yx)	0.000***	Output(Yx)	Govt.exp (G)	0.000***
Non ZLB					
Govt.exp (G)	Output(Yx)	0.000***	Output(Yx)	Govt.exp (G)	0.000***
Govt.exp (G)	Priv.con	0.533	Priv.con	Govt.exp (G)	0.000***
Govt.exp (G)	Priv.inv	0.000***	Priv.inv	Govt.exp (G)	0.000***
Govt.exp (G)	CCI	0.003***	CCI	Govt.exp (G)	0.634
ZLB					
Govt.exp (G)	Output(Yx)	0.000***	Output(Yx)	Govt.exp (G)	0.000***
Govt.exp (G)	Priv.con	0.004***	Priv.con	Govt.exp (G)	0.480
Govt.exp (G)	Priv.inv	0.000***	Priv.inv	Govt.exp (G)	0.009***
Govt.exp (G)	CCI	0.001***	CCI	Govt.exp (G)	0.452

The statistical significance is denoted by ***, ** and * are 1 %, 5% and 10% -levles respectivly

The consumption and investment models' results are more mixed. Government expenditure granger causes consumption in periods of ZLB but not in regular periods. On the other hand, consumption granger causes government expenditure in regular periods but not in ZLB periods. Between government expenditure and investment in both periods, there is reverser causality in both periods. The conclusion from the CCI model is that it is a clear one-way relationship where government expenditure granger causes CCI in all periods. However, the same can not be said for the other variables. Thus, most causal relationships are ambiguous, except for government expenditure and CCI. In order to determine the validity of the multipliers and the conclusions from this chapter, their robustness is tested in the next chapter.

5.3 Robustness analysis

The robustness analysis is divided into two parts. The first part tests the model sensitivity to changes in the number of lags used. The second part is an analysis of the multiplier's sensitivity to changes in the periods that are used. The first tests serve to verify the size of the multiplier's legitimacy and the choice of lags. The goal of the second robustness test is to conclude if the size of the multiplier is dependent on the state of the interest rate or if the state of the business cycle is a more important factor.

5.3.1 Lag sensitivity analysis

As ascertained in subchapter 5.1.1, the MAIC and MQIC criteria recommend estimating a model with four lags, but the MBIC recommends that one lag is the optimal lag amount. Thus, all models are reestimated using only one lag to test the robustness of the result from chapter five. New estimates of the models are made, and new multipliers are calculated. Every aspect of the models is the same besides the number of lags used. If there are changes, the results may largely depend on the number of lags used in the model[15]. The problem with sensitive models is that it is harder to draw valid conclusions since the model is lag dependent. The models are thus not generalizable. Granger causality test results for all models can be seen in table B.10 in appendix B. All models are stable, and the eigenvalue test can be seen in figure B.11 in Appendix B.

[15] To iterate, all three original benchmark modeless $[G_{it} \ Y_{it} \ \pi_{it}]$ are reestimated using one lag (the ZLB model, the non-ZLB model, and the whole period model). The private output ($[G_{it} \ Yx_{it} \ \pi_{it}]$), consumption ($[G_{it} \ PC_{it} \ \pi_{it}]$), and investment models ($[G_{it} \ PI_{it} \ \pi_{it}]$) are also reestimated using one lag.

Figure 5.8 illustrates the multiplier's peak and average size throughout the period. The multiplier's peak and average size are used to indicate how sensitive the model is since it can easily be compared to the result from the original. In Appendix B, all sensitivity analysis alternative model OIRF graphs are depicted in figures B12-B14. Figure 5.8 compares the lag sensitivity analysis test multipliers to the benchmark multipliers. The peaks of all benchmark model multipliers are considerably lower than their counterparts in chapter five. The average sizes of the multipliers are also lower than that of the benchmark models. Nevertheless, the ZLB multiplier has the largest size meaning that overall periods of ZLB still exhibit the most prominent multiplier.

The size of the multipliers from the private output model is also smaller than its counterparts in chapter five, with the non-ZLB multiplier having a negative peak and overall value, indicating a crowding out effect of fiscal policy on privet consumption and investment. However, for the private output model, the ordering of the sizes is still the same, with periods of ZLB having the most prominent multiplier followed by the entire period and non-ZLB periods, in line with the assumptions made from the IS-LM model.

The differences in the size of the consumption multiplier are not large between the original consumption model and the lag sensitivity test, indicating that the consumption multiplier model gives a relatively correct size of the multiplier or that one lag is enough to estimate the consumption multiplier. In the investment model, there is a considerable difference in the size of the multipliers in both periods, indicating that the investment multiplier is sensitive. The silver lining is that the IS-LM model theory holds since the multiplier is still considerably more extensive in periods of ZLB.

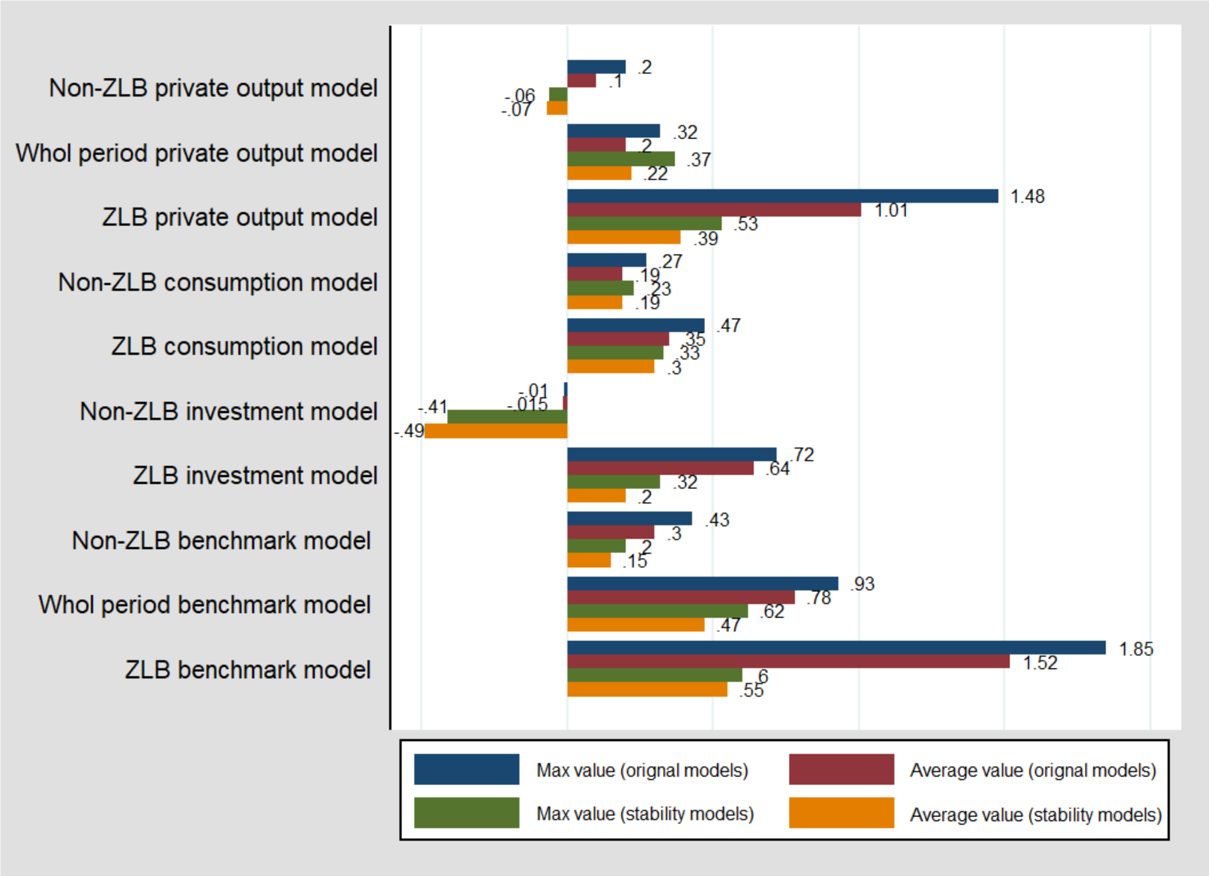

Figure 5.8: Lag sensitivity analysis. The figure illustrates the maximum and average values of the multiplier in different models.

In conclusion, only the size of the consumption multiplier has a somewhat robust multiplier size, and the rest of the multipliers are sensitive to the number of lags used. There can be two explanations for the phenomena. The first explanation is that one lag is not a valid model, and the models exhibit a down-word bias. Using one lag may explain that the down-word bias does not possess enough explaining power, and more lags are needed for a valid result. A further test would be to estimate the mode of all models with two, three, and five lags, compare the result, and determine the sensitivity.

Nevertheless, the lag selection criteria do not recommend that models with two, three, and five lags are optimal. The other explanation is that the usage of one lag is valid. However, the models and the variables are sensitive, meaning that the size of the multipliers from the original model is questionable and can not be thought of as a completely accurate multiplier.

The theory from the IS-LM model still holds up since the multipliers are still more prominent in periods of ZLB. This thesis's central question is to determine whether fiscal policy is more effective at stimulating the economy during periods of ZLB, so the analysis can still be conducted. However, the multipliers are only partially accurate and can thus only be used as an indicative tool to analyze the effect on aggregated demand rather than an exact measurement.

5.3.2 Period sensitivity analysis

This subchapter aims to analyze how the choice of the sample period impacts the multiplier. As mentioned earlier, the multiplier's size may largely depend on the state of the business cycle rather than the interest rate. If an economy is a rescission, the output is not at its natural level, and there is thus free capacity in the economy. Ramey & Zubairy (2018) conclude that fiscal policy is more effective at stimulating the economy when there is a large amount of free capacity, meaning that aggregated demand is not at its natural level. There is a possibility that the result from the original models reflects that multipliers tend to be more prominent during downturns rather than reflecting that multipliers are more extensive in ZLB periods. In both the analyzed periods, there are extensive recessions.

Figure 5.9 depicts the original EA countries' aggregated business[16] cycle. The recession periods are excluded from the models by dividing the periods into recessionary and non-recessionary periods. There were no recession periods before the financial crises. Thus, the period used for the non-ZLB period is 1999-2008. In the ZLB period, the euro crisis started circa 2011 and ended in 2013. These years will thus be excluded from the analysis, and the ZLB period is redefined as starting from 2014 and ending in 2019 (2020 will not be included because of the Corona crisis.) The causality test will thus be conducted by excluding the financial, euro, and Corona crisis years from the analysis. A third period is estimated and analyzed. This period is the rescission and stretches from 2008-2014. The third model is added to compare the two other periods to a recessionary period.

As in chapter 5.3.1, all models are reestimated[17], and peak and average multipliers are compared to their original model counterparts in their original models, with the only difference being the periods used. The models' variables, lags, and instruments used are the same as in chapter five.

[16]The aggregated changes in GDP are the average change in GDP for all the original EA countries for every year from 1999-2021. In any given quarter, all EA countries have different values for the change in GDP. The aggregated change is hence the average change of all countries combined.

[17] To iterate, all three benchmark modeless $[G_{it} \ Y_{it} \ \pi_{it}\ ]$ are reestimetad with the periods ZLB non-recession, non-ZLB non-recession and recession. The private output ($[G_{it} \ Yx_{it} \ \pi_{it}\ ]$), consumption ($[G_{it} \ PC_{it} \ \pi_{it}\ ]$)and investment model ($[G_{it} \ PI_{it} \ \pi_{it}\ ]$) are reestimated with the periods ZLB non-recession, non-ZLB non-recession and recession.

Granger causality test results for all models can be seen in table B.11 in appendix B. All alternative model OIRF graphs are depicted in figures B16-19 in Appendix B. All models are stable, and the eigenvalue test can be seen in figure B.11 in Appendix B.

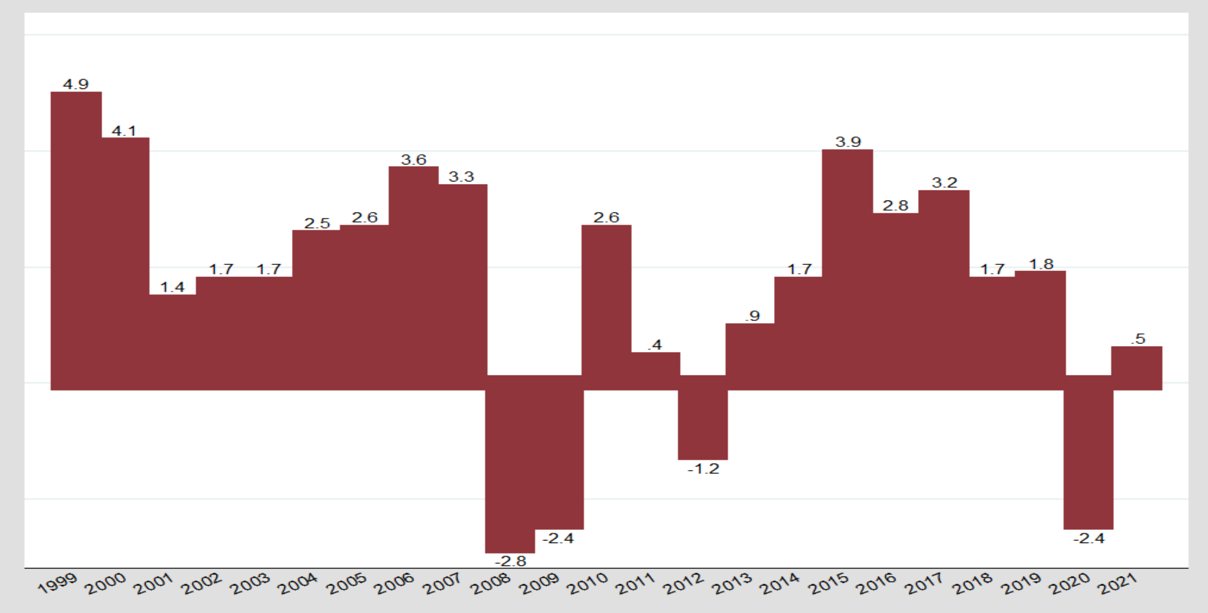

Figure 5.9: Depicts the changes in GDP for the EA for the period 1999-2021.

All the period sensitivity analysis model's multipliers are gathered in figure 5.10. There are some vital differences between multipliers from chapter five. The sizes of the benchmark multipliers are, for example, smaller in the period sensitivity analysis than in their counterparts in the original models. The multipliers from the ZLB period not containing recession periods exhibit a peak of 0.25 and an average of only 0.015. Non-ZLB periods without rescission periods show the corresponding values of 0.06 and -0.034. The recession benchmark model's peak and average multipliers are 1.25 and 1.06, respectively. The findings indicate that multipliers tend to be far larger during recessions following assumptions from standard macroeconomic theory.

The private output model detects similar conclusions as in the previous paragraph. The multipliers for non-ZLB periods are far smaller than their original model counterparts. The ZLB multipliers are likewise more diminutive than their original model equivalents. The recession multipliers are again the largest of the bunch, with a peak and average multiplier of 0.95 and 0.47. The conclusions are similar to the benchmark model: multipliers are more prominent during recessions in all scenarios.

The private consumption models show similar results as the two previous models. In periods of ZLB but no recession, the stimulating effect on consumption is more prominent than in non-ZLB periods, but the overall ZLB non-recession multiplier is minimal. The recession period multipliers are the most prominent, indicating that an increase in spending drives up consumption when the aggregated demand is not at its equilibrium level. The multipliers during non-ZLB periods without recession are, however, almost nonexistent, below 0.1, indicating that a shock in government expenditure has little effect on private consumption.

The private investment models differ the most from their original equivalents. In non-ZLB periods without a recession, there is now a considerable crowding out effect of private investment when the government increases its spending. In periods of ZLB without a recession, the government expenditure hardly stimulates private investment with peak and average multipliers below 0.1, which are far smaller than tier original model counterparts. In contrast, the investment multipliers during recession periods are sizable, with a peak and average multiplier of 1.71 and 0.98, respectively. These multipliers are far more prominent than the original ZLB investment multipliers, indicating the relative importance of the business cycle and the investment reaction.

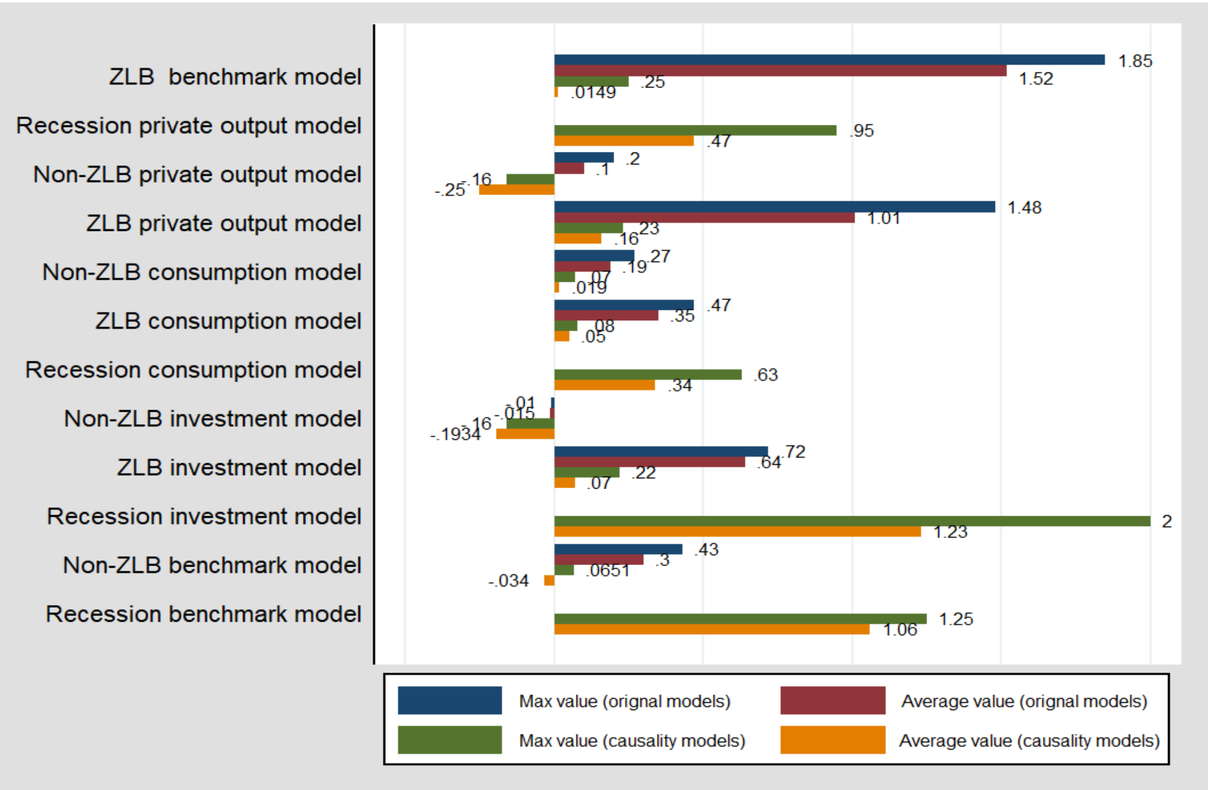

Figure 5.10: Period sensitivity analysis. The figure illustrates the maximum and average values of the multiplier in different models.

The conclusions from the period sensitivity analysis test are twofold. Firstly, a large part of the differences in the size of the fiscal multipliers can be attributed to the business cycle rather than the state of the interest rate. The recession period multiplier is the only one that stimulates the economy considerably. Secondly, fiscal policy has a larger multiplier in periods of ZLB since the multiplier is still, in all scenarios, far larger in periods of ZLB, which is in line with the IS-LM model predictions. However, the stimulating effect is negligible and deficient if the economy is not in a recession.

In conclusion, all multipliers in ZLB periods without recession are positive but smaller than one, indicating a negligible stimulating effect on the real economy. In non-ZLB periods without a recession, the conclusions are dismal. The increase in government expenditure seemingly has a crowding out effect in all variables except private consumption, which only has a trivial effect.

5.4 Result discussion

The evidence of this thesis suggests that the assumptions from the IS-LM model are accurate, the assumption being that of a larger fiscal multipliers in periods of ZLB. Thus, fiscal policy is more efficient at stimulating the economy when the economy is at the ZLB. The driving factor of the larger multipliers is the investors' reaction to the increase in government expenditure and, to a lesser extent, the consumer reaction.

Figure 5.11 illustrates the differences between the multipliers in the two periods for the GDP, private output, private consumption, and private investment multipliers. The upper bar chart in figure 5.11 depicts the multiplier when recession periods are included in the estimate. The lower bar chart depicts the multiplier when recession periods are excluded. The size of the benchmark multipliers in both periods is in line with the previous reaches and the assumptions of the IS-LM model. The difference between the fiscal multipliers in periods of and without ZLB is sizeable in all scenarios. In periods of ZLB, the fiscal multiplier averages 1.52 compared to 0.3 in non-ZLB periods.

The reaction in consumption is also more prominent in periods of ZLB with a consumption multiplier of 0.47 compared to the non-ZLB consumption multiplier of 0.27. However, the difference is less prominent than for the other variables. The consumers' future expectations are an essential factor. However, as concluded from the CCI model, there is an increase in the CCI in both periods. Nevertheless, the increase does not last long, and consumer confidence vain quickly after the shock in government expenditure. The limited response lends credence to the decision to exclude Ricardian equivalence for consumers.

In short, an increase in government expenditure has a crowding in the effect of private consumption in both periods. The assumptions from the IS-LM model correctly predict that the crowding in the effect of private consumption is more immense during periods of ZLB, which is caused by the more considerable rise in the consumer's future expectations. However, the consumption reactions only partly explain the difference in the fiscal multiplier between the periods.

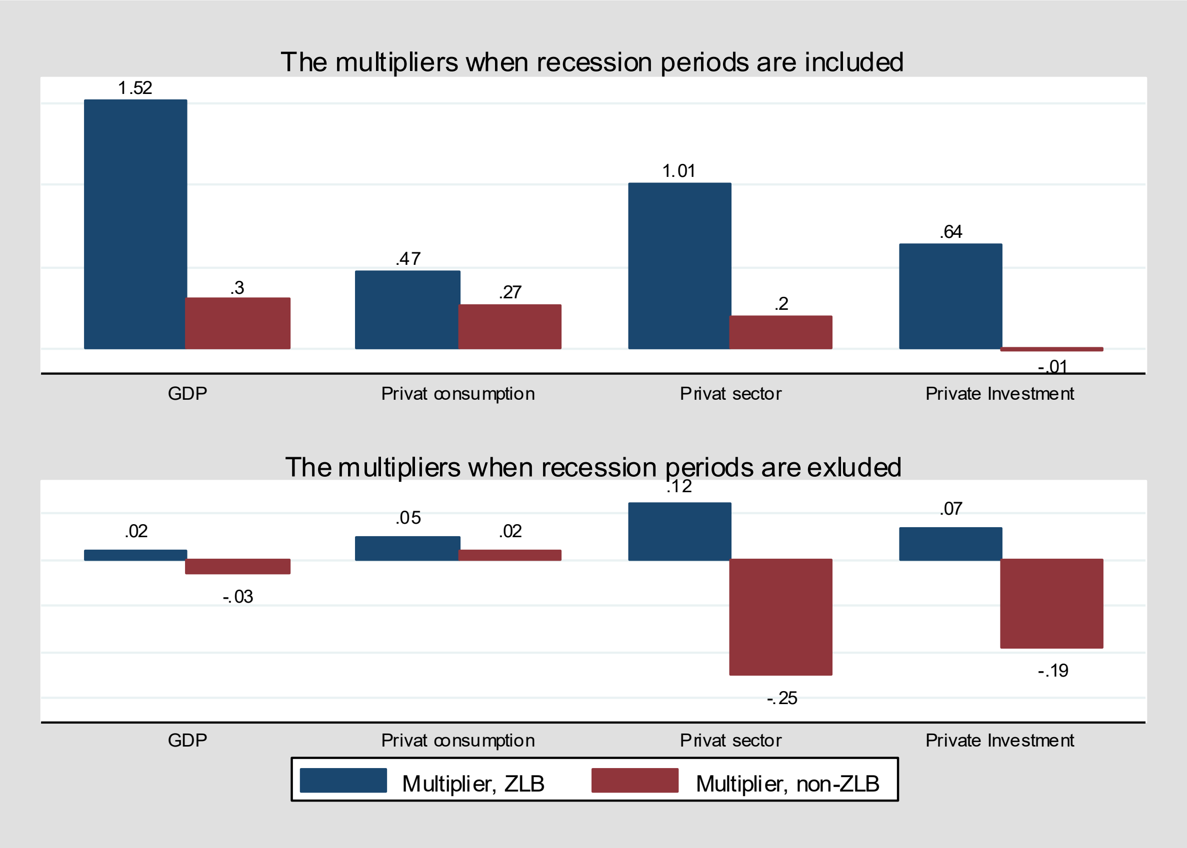

Figure 5.11: Summarization of the multipliers for the models $[G_{it}\ Y_{it}\ \pi_{it}]$, $[G_{it}\ Yx_{it}\ \pi_{it}]$, $[G_{it}\ PC_{it}\ \pi_{it}]$ and $[G_{it}\ PI_{it}\ \pi_{it}]$. The upper bar chart showcases the models with recession periods included in the model and the lower with excluded recession periods.

The investor's reaction can explain the lion's share of the difference in the multiplier size. The reactions of the investors differ remarkably between the periods. Only in periods of ZLB is there crowding in of investment. In contrast, during non-ZLB periods, a weak crowding out of investments is observed. The investment factor can largely be explained by the interest rate and the investors' confidence, as predicted by the IS-LM model. The differing nature of consumption and investment expenditure might also explain investors' relatively more critical status.

Consumers possess base needs that need to be met, no matter the state of the interest rate or the business cycle. The base needs include food, clothing, necessary car reprises, housing repairs, and other products of a similar nature. Thus, consumers might be unable to adjust their consumption based on external events unless the events are severe. The IS-LM model assumption of the rational and forward-looking preferences of the consumers might not be as strong as the model assumes.

However, investors might be more able to adjust their investments based on the interest rate or business cycle state. A business's profitability tends to shrink when there is a contraction in the economy. Since a company has fixed costs and fixed variable costs (in the short term) that need to be met, the first expenditure decrease is thus in investments. The investments might be terminated entirely or delayed into the future when the business cycle has normalized, or the interest rate is more favorable. The increase in investment spending due to fiscal policy can thus be caused by the reassuring effect of the government expenditure on the company's future expectations. The expansive fiscal policy thus encourages companies to refrain from delaying their investment or even encourage them to make new investments for investment opportunities that arise when the government increases its expenditure, but there is no increase in the interest rate.

When the government increases its expenditure in non-ZLB periods without a recession, the costs must be paid by borrowing or increasing taxes. The tax increase has a contrastive effect on investment if it impacts companies. The increase in borrowing may also crowd out investment by bond-financed crowding out[18]. The rise in the interest rate has a twofold crowding out effect on investment. Higher interest means that borrowing becomes more expensive (lowering the marginal efficiency of capital[19]), and simultaneously investment in

[18] Musgrave (1959) explains that Bond-financed crowding out can occur because public borrowing drives up interest rates and because capital is concentrated in government bonds and thus away from other sorts of investments.

[19] The marginal efficiency of capital (MEC) is a discount rate required to equalize the price of an investment with the present value of the discounted expected income (Keynes, 1936)

government bonds becomes more lucrative. If the economy is at the ZLB, bond yields are likely to also be low, which reduces the lucrative of investments in bonds.

For example, if an investor chooses between investing in a machine with a forecasted yearly return of 4% and interest on a loan is 3%, the gain of the investment will thus be 1%. The bond is preferred if an equivalent amount of money is invested in a government bond with a yearly return of 4%. The choice of the bond is due to the liquidity preference[20]. The increased investment in government bonds will thus crowd out other sorts of investment. In periods of ZLB without a recession, investors are mainly indifferent to the increase in government expenditure since it does not raise the interest on their loans, and the return on investment in government bonds is meager.

The lower bar chart in figure 5.11 displays the ZLB and non-ZLB period multipliers if recession periods are excluded. The multipliers are far smaller than their counterparts, with recession periods included. The fiscal multiplier is insignificant in ZLB non-recession and has a small crowding out effect in non-ZLB non-recession periods. The consumption multiplier differs marginally between the two periods. However, the multipliers' overall size in both periods is notably smaller than when recession periods are included in the model. However, the investment multiplier sees an enormous difference. The ZLB non-recession investment multiplier is negligible compared to the original multiplier. The non-ZLB non-recession investment multiplier exhibits an even larger crowding out effect when recession periods are excluded. However, the conclusion of a larger multiplier in the period of ZLB persists in every scenario. In conclusion, there is no large recorded multiplier when the economy is not in a recession, but overall the multipliers tend to be more prominent in ZLB periods.

This study's findings are consistent with previous research on the topic. The ZLB multiplier of 1.52 is comparable to the multipliers reported by Bonam et al. (2022), Miyamoto et al. (2018), and Ramey & Zubairy (2018), which were 1.6, 1.5, and 1.5, respectively. These results suggest that the EA, like the OECD, the United States, and Japan, experiences large multipliers during periods of ZLB. As EA countries are part of the OECD, they were expected to have similar multipliers. However, the non-ZLB multiplier of 0.3 is somewhat lower than the multipliers

[20] The liquidity preference means that investors prefer to have their money liquid. Investors thus prefer more liquid option investment options such as bonds.

reported by other studies, which ranged from 0.4 to 0.6. This difference may be due to regional variations, as the EA might have had smaller multipliers during non-ZLB periods.

Miyamoto et al. (2018) studied consumption and investment multipliers. The findings of Miyamoto et al. (2018) suggest that the average non-ZLB multiplier is -0.2, with a peak of 0.2. Miyamoto et al. (2018) multipliers are relatively smaller than the non-ZLB multipliers in this thesis, but they align with the non-recession consumption multipliers. The Miyamoto et al. (2018) ZLB consumption multipliers also differ, with an average of 1.3 and a peak of 1.87. The investment multipliers estimated in the Miyamoto et al. (2018) study are similar to those found in the thesis, with an average and peak non-ZLB investment multiplier of -0.06 and -0.01, respectively. Furthermore, the corresponding ZLB investment multipliers are 0.65 and 1.04, respectively. Notably, the Miyamoto et al. (2018) study was conducted on Japan from 1980 to 2014, which affects the estimated multipliers. However, in Miyamoto et al. (2018), multipliers are more prominent during ZLB periods, which is consistent with the conclusions with the result from this thesis.

One noteworthy discovery of the thesis is that government expenditure in isolation does not induce extensive inflation. While a surge in inflation was detected several quarters subsequent to a shock in government expenditure, it appears to be more strongly linked to a rise in aggregate demand. In cases where government expenditure does not result in output growth, inflation remains unaffected. Nevertheless, the study's conclusion suggests that using fiscal policy to exit the liquidity trap in non-recessionary circumstances is unfeasible.

As concluded in chapter 5.3.1, all the multipliers estimated in this thesis are sensitive to changes in the number of lags chosen. The conclusions on what may cause the sensitivity were twofold. Firstly, the selection criteria recommended using one or four lags, and the test was conducted by changing from four to one lag. However, one lag might not be the optimal model for the analysis. Secondly, the variables and the models might be sensitive, meaning that the size of the multiplier is questionable and can not be considered an accurate multiplier. However, the conclusion of a larger multiplier in the period of ZLB holds in every scenario.

As indicated by the results from the Ganger causality test, the causal relationship between the government expenditure on the other variables besides CCI and private consumption is left ambiguous. The validity of the variable exogeneity thus relies entirely on the modeling choices. The modeling choices are the usage of recursive identification and GMM instruments.

The thesis goal was to contribute to the current literature with an analysis of a Euro area-specific fiscal multiplier, the usage of PVAR with GMM instruments (both to tackle the endogeneity problem and allow for the usage of shorter time frames), the causality of larger multipliers in periods of ZLB and the ability of fiscal policy to jumpstart an economy in periods of ZLB. Three of these four goals were met, and one was partially met.

The more robust response of the economy to fiscal stimulus in periods of ZLB was concluded. However, the evidence of this thesis indicates that governments can only effectively stimulate the economy in periods of recession. The evidence suggests that fiscal expansions meant to curb growth recessions are not possible due to mainly a weak response of private investment in ZLB periods and a crowding out effect in non-ZLB periods. Using PVAR with instrumented lagged variables seemingly works and gives valid results while minimizing the problem with endogenous effects. An EA-specific multiplier was estimated to be similar to fiscal multipliers for other regions in previous literature. The multiplier's size validity is questionable due to the model's sensitivity to changes in the number of lags used.

6. Conclusions

This thesis investigates the impact of the ZLB on the effectiveness of fiscal policy by analyzing fiscal multipliers in various scenarios for the original Euro Area (EA) countries. These countries were selected due to their lack of independent monetary policy, relative homogeneity, and extended periods of ZLB, making them a suitable group to study in this context. Additionally, the inability of the EA to coordinate monetary and fiscal policy imposes more pressure on fiscal stimulus. The thesis aims to assess whether the persistence of the ZLB could positively affect the capacity of individual EA countries to independently stimulate their economies without the involvement of the European Central Bank (ECB). The analysis leads to three main findings:

1. The stimulating effect of fiscal policy is more prominent in periods of ZLB than in non-ZLB periods.
2. The size of the multiplier primarily relies on the response of consumers and investors, but it is even more contingent on the reaction of private investment.
3. If the economy is not in recession, fiscal policy has a lackluster effect on the aggregated demand in periods of ZLB and a crowding out effect in non-ZLB periods.

The fiscal multipliers during ZLB periods and non-ZLB periods are found to be 1.52 and 0.30, respectively. The larger multiplier during ZLB periods is attributed in part to an increase in consumers' future expectations when there is significant fiscal expansion. However, differences in consumer response can not solely account for the variation between ZLB and non-ZLB periods. Instead, the reaction of private investment provides a sufficient explanation for the discrepancy in size between the two periods. The investment response is thought to be related to the level of interest rates. In a ZLB environment, changes in government spending have a limited impact on private investment. While interest rates are likely to influence consumers due to the effect of existing interest rates on loans, a substantial portion of consumption is not reliant on the interest rate.

By controlling for the state of the business cycle and estimating new multipliers for the following periods, non-ZLB non-recession, ZLB non-recession, and recession are estimated. The results indicate that large fiscal multipliers are only present in recessionary periods. In periods of recession, the effects on total output, privet consumption, and private investment are positive and sizable. In the non-ZLB non-recession periods, an increase in government spending caused trivial gains in total output. The weak gains can largely be explained by a sizable crowding out of private investment and an inconsequential response in consumption. In contrast to the non-ZLB non-recession period, the ZLB non-recession period sees no crowding out. Nevertheless, the gains in private consumption and investment are considerably smaller than the ZLB periods with recessions.

To conclude, fiscal policy is most effective in periods of recession. However, overall, the multiplier tends to be larger in periods of ZLB than in non-ZLB periods. The implications of the thesis results are the following for policymakers. Conducting fiscal expansions stimulates aggregated demand when the economy is in a recession. Conducting expansive fiscal policy in non-ZLB non-rescission periods has a crowding out effect on private investment. Conducting expansive fiscal policy in ZLB non-rescission does not exhibit a crowding out effect, but the economic gains are primarily limited to increased government expenditure.

In order to economically optimize large government expenditures, programs such as the "Green New Deal" should be implemented in periods of recession or depression. The small size of the fiscal multipliers in periods of ZLB without recession indicates that fiscal expansions are ineffective for ending growth recessions or pushing the economy out of a liquidity trap. However, the analysis also indicates governments can implement large spending programs during ZLB without crowding out private incitement. Ambitious EA spending programs can thus be implemented with the cavitate that the governments must finance the programs with future higher taxes or deficit spending. This thesis is only concerned with the short-term effects of fiscal policy. Thus, the conclusion that government investments aimed at infrastructure, optimizing energy usage, and much more are not socially and economically beneficial in the long run should not be drawn from this study.

The thesis verifies that fiscal multipliers are more prominent in periods of ZLB. Further research is needed to estimate country-specific multipliers for each of the EA. A deeper dive into what sort of investment and consumption is most impacted by fiscal policy could help governments to minimize crowding out. A more meticulous analysis of individual government programs is needed to estimate accurate multipliers in-both periods. A more meticulous analysis could be conducted on a spending program basis and measured on a microeconomic level. Machine learning models could be trained to estimate the correlation over time between government investment programs and economic indicators, which could be used to calculate accurately micro-based program-specific multipliers. The same Machine learning models could also be used to compare the program multipliers in both periods with and without ZLB.

7. Summary in Swedish – Svensk sammanfattning

Euroområdet har präglats av ett antal ekonomiska kriser under tvåtusentalet. Traditionell har centralbanker den främsta rollen inom bekämpning av ekonomiska kriser. Inom euroområdet är det Europeiska centralbanken (ECB) som sköter penningpolitiken. ECB:s främsta verktyg för att styra ekonomin är justering av styrräntan. En rad olika orsaker har dock lett till att ECB inte kan stimulera euroområdets ekonomier effektivt. För det första är länderna olika och kräver olika åtgärder, och ECB kan nödvändigtvis inte ta hänsyn till dessa olikheter. För det andra har ECB enbart som mål att hålla prisnivån stabil, vilket lämnar de enskilda länderna inom euroområdet att självstyrt bestämma majoriteten av den övriga ekonomiska aktiviteten. För det tredje har styrräntan varit noll eller nära noll sedan finanskrisen 2008. Den låga styrräntan gör att ECB har tappat förmågan att stimulera ekonomin effektivt, styrräntan har således mött sin nedre nollgräns, på engelska ”Zero Lower-Bound” (ZLB).

När coronakrisen inträffade befann sig beslutfattarna i en situation där de inte visste hur de bör stimulera ekonomin effektivt då styrräntan var noll. Krugman m.fl. (1998) föreslår att man bör tillförlita sig på finanspolitiken för att stimulera ekonomin i ZLB. Argumenten för att använda finanspolitik är följande: Man kan relativt snabbt och med en större noggrannhet stimulera ekonomin, därutöver är enbart penningpolitik är inte tillräcklig för att stimulera ekonomin i ZLB. Dessutom finns det teoretisk grund för att anta att finanspolitik är mera effektivt i perioder av ZLB. Effektivitet av finanspolitikens kan mätas genom att kalkylera en multiplikator för finanspolitiken. Multiplikatorn står för hur mycket effekt en ökning i offentliga utgifter har på ekonomin som helhet, till exempel om staten höjer sina utgifter med en enhet och den ekonomiska aktiviteten ökar med en enhet så är multiplikatorn ett.

Målet med denna avhandling är att undersöka om finanspolitiken har en större multiplikator i ZLB-perioder och hur beslutfattare kan utnyttja situationen. Denna typ av analyser har gjorts tidigare. Merparten av de tidigare studierna är dock gjorda med teoretiska modeller som till exempel i Johannsen (2014) & Aursland et al. (2020). De teoretiska analyserna lider dessvärre av brist på empiriskt bevis. ZLB är ett sällsynt fenomen och data i perioder var icke-tillräcklig för att göra en empirisk analys tidigare. Mellan 2012 och 2021 var räntan noll eller nära noll i euroområdet. Den långa ZLB-perioden har möjliggjort empirisk analys. Bonam m.fl. (2022) var bland de första som gjorde en empirisk analys av finanspolitik i ZLB.

Denna studie bidrar på fyra sätt till den befintliga litteraturen. För det första vidareutvecklas en liknande empirisk modell som Bonam m.fl. (2022) använder. Vidareutvecklingen görs för att få ett mera noggrant estimat och för att möjliggöra användningen av kortare tidsperioder. För det andra estimeras en aggregerad multiplikator för hela euroområdet. För det tredje analyseras den expansiva finanspolitikens förmåga att skuffa en ekonomi ur en likviditetsfälla. För det fjärde analyseras kausaliteten av ZLB på finanspolitiken. I studien definieras finanspolitik som summan av offentlig konsumtion och investeringar. Jag studerar därmed enbart expansiv finanspolitik i form av en ökning i offentliga utgifter.

Perioden som analyseras sträcker sig från 1999 till 2021. Valet av period stöds av att euroområdet bildades 1999 och det finns data fram till slutet av 2021. Data är på kvartalsbasis och länderna som ingår är Tyskland, Frankrike, Italien, Spanien, Finland, Nederländerna, Belgien, Österrike, Portugal och Irland. Länderna väljs utifrån att de anslöt sig till den monetära unionen samtidigt, vilket därmed betyder att det finns rikligt med data för både perioder med och utan ZLB. För att möjliggöra analysen delas perioden upp i 1999 - 2012 som representerar icke-ZLB-perioden och 2012 - 2021 som representerar ZLB-perioden. Valet av perioder görs utifrån nivån på styrräntan.

Avhandlingens teoretiska grund består av en IS-LM modell som tar hänsyn till konsumenters framtidsförväntningar och är utvecklad av Koenig (2011). IS-LM modellen används för att förklara varför effektiviteten av expansiv finanspolitik skiljer sig mellan perioder med och utan ZLB. IS-LM modellen predikterar att multiplikatorn i perioder av ZLB är större på grund av att den höjer konsumenternas framtidsförväntningar. Det samma sker i icke-ZLB-perioder men effekten stramas av omfördelning av kapital som leder till att räntan höjs. Höjningen sker inte i ZLB-perioder.

För att bevisa de teoretiska antagandena används metoden vektorautoregression (VAR). Blanchard & Perotti (1999) har utvecklat en metod som möjliggör analyser av expansiv finanspolitik med en VAR-modell. Modellen kräver dock att finanspolitik definieras som summan av offentlig konsumtion och investeringar och är på kvartalsbasis. Definitionen gör det möjligt att estimera en exogen chock i VAR-modellen, exogenitet krävs för att estimera en giltig VAR-modell. Användningen av paneldata möjliggör estimering av en aggregerad multiplikator för euroområdet. Valet att estimera en aggregerad multiplikator för euroområdet görs för att kontrollera för selektionsproblemet och för att ha tillgång till en större databas, vilket torde resultera i ett mera noggrant estimat.

Panel-VAR-modellen (PVAR) tillämpas i enlighet med Bonam m.fl. (2022) tidigare PVAR-modell. Abrigo & Love (2016) konstaterar dock att estimering av panelmodeller med endogena variabler leder till bias i estimaten. Abrigo & Love (2016) rekommenderar att göra om de laggade värdena på variablerna till instrument som inte korrelerar med feltermen utan enbart med de andra variablerna. Metoden GMM används för att konstruera instrumenterade laggade variabler som kontrollerar för landsfixa effekter. Modellen som används i avhandlingen är därmed en PVAR-modell med instrumenterade variabler.

Analysen görs genom att estimera två referenspunktsmodeller, en för perioder med ZLB och en utan ZLB. Modellerna innehåller variablerna total offentliga utgifter (G), BNP (Y) och inflation (π). En chock i offentliga utgifter simuleras och dess effekter mäts på de två andra variablerna. Multiplikatorn konstrueras utifrån hur BNP reagerar på chocken. Analysen fördjupas genom att byta ut BNP mot variablerna privat konsumtion (PC), investering (PI) och konsumentförtroendeindex (CCI). Privat konsumtion och investering används dels för att fördjupa förståelsen för hur offentliga utgifter påverkar ekonomin och dels för att granska de antaganden som görs i IS-LM modellen. Konsumentförtroendeindexet analyseras för att bekräfta hur konsumenternas framtidsförväntningar påverkas av finanspolitik i de olika perioderna. Efter estimeringen bör robustheten av estimaten prövas.

Syftet med robusthetstesten är att granska modellens känslighet och att bekräfta räntans roll. Perioder av lågkonjunktur antas signifikant påverka multiplikatorns storlek. Teoretiskt sett är multiplikatorn större under lågkonjunktur på grund av att det finns ledig kapacitet i ekonomin. Den lediga kapaciteten gör att offentlig stimulering är mera effektiv. I praktiken betyder detta att perioden delas upp i tre perioder och multiplikatorer estimeras för varje period. Perioderna är följande: en period där ekonomin varken befinner sig i lågkonjunktur eller ZLB, en period med ZLB men inte lågkonjunktur och slutligen en period med enbart lågkonjunktur.

För perioder med ZLB estimeras en multiplikator med storleken 1,52 och för perioder utan ZLB en multiplikator på 0,30, vilket är i riktlinje med den tidigare litteraturen. Utvecklingen av multiplikatorerna är också i riktlinje med utvecklingarna av multiplikatorer i den tidigare litteraturen. Storleken på multiplikatorerna understöder därmed IS-LM modellens validitet.

Analyserna av privat konsumtion och investering följer de teoretiska antaganden ur IS-LM modellen. Resultaten tyder också på reaktionen i privata investeringar är överlag viktigare samt så är investerings graden mera känslig för ZLB. Resultaten av CCI-analysen följer de teoretiska antagandena. Effekten på CCI som följd av expansiv finanspolitik är dock kortvarig i alla perioder och det förklarar varför privata investeringar har en större betydelse för multiplikatorns storlek. Slutligen konstateras det att lågkonjunktur är en viktig faktor för storleken på multiplikatorn.

Följande centrala slutsatser kan dras från alla estimerade modeller: den stimulerande effekten av finanspolitiken är mer framträdande i perioder med ZLB än i icke-ZLB-perioder, den mer framträdande stimulerande effekten är beroende av konsumenternas och investerarnas reaktion men, i större utsträckning, beroende av reaktionen på privata investeringar. Om ekonomin inte är i en lågkonjunktur har finanspolitiken en obetydlig effekt på den aggregerade ekonomin i perioder med ZLB och en utträngningseffekt i icke-ZLB-perioder. I perioder av lågkonjunktur har finanspolitiken en stark positiv effekt på ekonomin.

Sammanfattningsvis är finanspolitiken mest effektiv i perioder av lågkonjunktur. Totalt sett tenderar dock multiplikatorn vara större i perioder med ZLB än i icke-ZLB-perioder. Implikationerna av avhandlingens resultat är följande för beslutsfattare: 1) att genomföra finanspolitiska expansioner i en ZLB-miljö stimulerar den aggregerade efterfrågan när ekonomin är i en lågkonjunktur, 2) expansiv finanspolitik har en utträngningseffekt på privata investeringar om den bedrivs i vanlig konjunktur och räntan är inte bunden i ZLB och 3) att bedriva expansiv finanspolitik i perioder av ZLB men inte lågkonjunktur har ingen utträngningseffekt. Den svaga storleken på de finanspolitiska multiplikatorerna i perioder med ZLB och utan lågkonjunktur indikerar att expansiv finanspolitiska är ineffektiva för att få slut på tillväxtrecessioner eller för att driva ekonomin ur en likviditetsfälla.

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Appendix A

In equations A.1 and A.2 the liner equation of Government expenditure G and output Y are depicted. Equation A.3 the equations A.1 and A.2 are divided into vectors. In equation A.4 the reduced VAR (1) model of G and Y is depicted, hence $Z_t = [G_t \; Y_t]$. Equation A.3 contains nine parameters: six coefficients, two variances, and one covariance. We obtain the estimation of six coefficients c and two variance-covariance matrices of residuals.

$$G_t = \xi_{10} + d_{11}G_{t-1} + d_{12}Y_{t-1} + u_t^G \tag{A.1}$$

$$Y_t = \xi_{20} + d_{21}Y_{t-1} + d_{22}G_{t-1} + u_t^Y \tag{A.2}$$

$$\begin{bmatrix} G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \xi_{10} \\ \xi_{20} \end{bmatrix} + \begin{bmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ G_{t-1} \end{bmatrix} + \begin{bmatrix} u_t^G \\ u_t^Y \end{bmatrix} \tag{A.3}$$

$$Z_t = \xi + \mathrm{D}Z_{t-1} + u_t \tag{A.4}$$

The unrestricted structural model is depicted in equation A.5. The structural model has ten unknowns. To identify the structural shock matrix (A) needs to be restricted. Equation A.6 depicts the un restricted SVAR(1) model. Equation A.7depicts the SVAR (1) with the restriction that coefficient a_{12} equals zero.

$$AZ_t = \xi + \mathrm{D}Z_{t-1} + u_t \tag{A.5}$$

$$\begin{bmatrix} 1 & a_{12} \\ a_{21} & 1 \end{bmatrix} \begin{bmatrix} G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \xi_{10} \\ \xi_{20} \end{bmatrix} + \begin{bmatrix} d_{10} & d_{11} \\ d_{21} & d_{20} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ G_{t-1} \end{bmatrix} + \begin{bmatrix} u_t^G \\ u_t^Y \end{bmatrix} \tag{A.6}$$

$$\begin{bmatrix} 1 & 0 \\ a_{21} & 1 \end{bmatrix} \begin{bmatrix} G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \xi_{10} \\ \xi_{20} \end{bmatrix} + \begin{bmatrix} d_{10} & d_{11} \\ d_{21} & d_{20} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ G_{t-1} \end{bmatrix} + \begin{bmatrix} u_t^G \\ u_t^Y \end{bmatrix} \tag{A.7}$$

In practice, the restriction on matrix A implies that Y has no contemptuous effect on G within a period. The Linear estimations post restriction is depicted in equations A.8 and A.9.

$$G_t = \xi_{10} + d_{10}G_{t-1} + d_{11}Y_{t-1} + u_t^G \quad \text{(A.8)}$$

$$Y_t + a_{21}G_t = \xi_{20} + d_{21}Y_{t-1} + d_{20}G_{t-1} + u_t^Y \quad \text{(A.9)}$$

Equation A.9 depicts the reduced form of a restricted SVAR (1) model, and equation A.10 depicts the vector form of the same SVAR (1). To recover the structural shocks and estimate Z_t, equation A.9 needs to be multiplied by the inverse matrix A matrix A-1. Note that the same restrictions imposed on matrix A will be imposed on its inverse. The final reduced SVAR (1) model is thus depicted in A.11.

$$A^{-1}AZ_t = A^{-1}\xi + A^{-1}D_1Z_{t-1} + A^{-1}u_t \quad \text{(A.9)}$$

$$\begin{bmatrix} G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -a_{21} & 1 \end{bmatrix} \begin{bmatrix} \xi_{10} \\ \xi_{20} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ -a_{21} & 1 \end{bmatrix} \begin{bmatrix} d_{10} & d_{11} \\ d_{21} & d_{20} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ G_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ -a_{21} & 1 \end{bmatrix} \begin{bmatrix} u_t^G \\ u_t^Y \end{bmatrix} \quad \text{(A.10)}$$

$$Z_t = \beta_0 + \beta_1 Z_{t-1} + e_t \quad \text{(A.11)}$$

The restrictions on matrix A will affect the entire system, most notably the forecast errors. The restrictions on the forecast errors are the implications of the structural shocks. A shock to G is depicted in equation A.12 and is hence the structural shock.

$$\begin{bmatrix} G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \xi_{10} \\ -a_{21}\xi_{10} + \xi_{20} \end{bmatrix} + \begin{bmatrix} d_{10} & d_{11} \\ -a_{21}d_{10} + d_{21} & -a_{21}d_{11} + d_{20} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ G_{t-1} \end{bmatrix} + \begin{bmatrix} u_t^G \\ -a_{21}u_t^Y + u_t^G \end{bmatrix} \quad \text{(A.11)}$$

Appendix B

Table B.1: Results from the Augmented Dicky-Fuller test France						
	Zeroth			First		
Variable	Test statistic	1% Critical Value	5% Critical Value	Test statistic	1% Critical Value	5% Critical Value
Govt.con	-2.39	-3.525	-2.899	-7.847	-3.528	-2.9
Govt.inv	-1.876	-3.525	-2.899	-8.301	-3.527	-2.9
Govt.tot	-1.897	-3.525	-2.899	-7.787	-3.528	-2.9
Real GDP	-1.717	-3.525	-2.899	-8.039	-3.527	-2.9
Priv.inv	-1.091	-3.525	-2.899	-4.656	-3.527	-2.9
Priv.con	-2.943	-3.525	-2.899	-3.911	-3.527	-2.9
CCI	-	-	-	-5.479	-3.527	-2.9
CPI	-	-	-	-3.951	-3.527	-2.9
Interest rate	-0.39	-3.525	-2.899	-7.842	-3.527	-2.9

Table B.2: Results from the Augmented Dicky-Fuller test Spain						
	Zeroth			First		
Variable	Test statistic	1% Critical Value	5% Critical Value	Test statistic	1% Critical Value	5% Critical Value
Govt.con	-2.26	-3.525	-2.899	-5.694	-3.527	-2.9
Govt.inv	-2.093	-3.525	-2.899	-7.057	-3.527	-2.9
Govt.tot	-1.637	-3.525	-2.899	-4.293	-3.528	-2.9
Real GDP	-3.076	-3.525	-2.899	-7.584	-3.527	-2.9
Priv.inv	-2.476	-3.525	-2.899	-3.637	-3.527	-2.9
Priv.con	-3.055	-3.525	-2.899	-3.278	-3.527	-2.9
CCI	-	-	-	-5.152	-3.527	-2.9
CPI	-	-	-	-5.347	-3.527	-2.9
Interest rate	-2.089	-3.525	-2.899	-4.736	-3.527	-2.9

Table B.3: Results from the Augmented Dicky-Fuller test Italy						
	Zeroth			First		
Variable	Test statistic	1% Critical Value	5% Critical Value	Test statistic	1% Critical Value	5% Critical Value
Govt.con	-4.55	-3.525	-2.899	-8.422	-3.528	-2.9
Govt.inv	-4.55	-3.525	-2.899	-11.215	-3.527	-2.9
Govt.tot	-5.174	-3.525	-2.899	-8.157	-3.528	-2.9
Real GDP	-2.543	-3.525	-2.899	-7.806	-3.527	-2.9
Priv.inv	-2.637	-3.525	-2.899	-4.353	-3.527	-2.9
Priv.con	-2.499	-3.525	-2.899	-3.913	-3.527	-2.9
CCI	-	-	-	-5.722	-3.527	-2.9
CPI	-	-	-	-4.386	-3.527	-2.9
Interest rate	-0.831	-3.525	-2.899	-6.2	-3.527	-2.9

Table B.4: Results from the Augmented Dicky-Fuller test Finland						
	Zeroth			First		
Variable	Test statistic	1% Critical Value	5% Critical Value	Test statistic	1% Critical Value	5% Critical Value
Govt.con	-2.175	-3.525	-2.899	-5.892	-3.528	-2.9
Govt.inv	-1.521	-3.525	-2.899	-7.926	-3.527	-2.9
Govt.tot	-2.233	-3.525	-2.899	-6.163	-3.528	-2.9
Real GDP	-1.614	-3.525	-2.899	-4.764	-3.527	-2.9
Priv.inv	-1.342	-3.525	-2.899	-4.277	-3.527	-2.9
Priv.con	-2.697	-3.525	-2.899	-3.531	-3.527	-2.9
CCI	-	-	-	-5.378	-3.527	-2.9
CPI	-	-	-	-5.325	-3.527	-2.9
Interest rate	-0.406	-3.525	-2.899	-7.396	-3.527	-2.9

Table B.5: Results from the Augmented Dicky-Fuller test the Netherlands						
	Zeroth			First		
Variable	Test statistic	1% Critical Value	5% Critical Value	Test statistic	1% Critical Value	5% Critical Value
Govt.con	-1.641	-3.525	-2.899	-7.213	-3.528	-2.9
Govt.inv	-2.291	-3.525	-2.899	-9.551	-3.527	-2.9
Govt.tot	-3.504	-3.525	-2.899	-6.520	-3.528	-2.9
Real GDP	-1.377	-3.525	-2.899	-6.998	-3.527	-2.9
Priv.inv	-1.053	-3.525	-2.899	-6.319	-3.527	-2.9
Priv.con	-1.778	-3.525	-2.899	-3.77	-3.527	-2.9
CCI	-	-	-	-5.859	-3.527	-2.9
CPI	-	-	-	-5.224	-3.527	-2.9
Interest rate	-0.322	-3.525	-2.899	-7.417	-3.527	-2.9

Table B.6: Results from the Augmented Dicky-Fuller test Belgium						
	Zeroth			First		
Variable	Test statistic	1% Critical Value	5% Critical Value	Test statistic	1% Critical Value	5% Critical Value
Govt.con	-2.42	-3.525	-2.899	-8.895	-3.527	-2.9
Govt.inv	0.357	-3.525	-2.899	-11.032	-3.527	-2.9
Govt.tot	-1.563	-3.525	-2.899	-9.702	-3.528	-2.9
Real GDP	-0.852	-3.525	-2.899	-7.974	-3.527	-2.9
Priv.inv	-0.613	-3.525	-2.899	-3.938	-3.527	-2.9
Priv.con	-1.488	-3.525	-2.899	-4.301	-4.302	-2.9
CCI	-	-	-	-6.143	-3.527	-2.9
CPI	-	-	-	-4.792	-3.527	-2.9
Interest rate	-0.473	-3.525	-2.899	-8.2	-3.527	-2.9

Table B.7: Results from the Augmented Dicky-Fuller test Portugal						
	Zeroth			First		
Variable	Test statistic	1% Critical Value	5% Critical Value	Test statistic	1% Critical Value	5% Critical Value
Govt.con	-2.823	-3.525	-2.899	-8.992	-3.528	-2.9
Govt.inv	-2.276	-3.525	-2.899	-10.740	-3.527	-2.9
Govt.tot	-2.363	-3.525	-2.899	-9.526	-3.528	-2.9
Real GDP	-2.049	-3.525	-2.899	-7.809	-3.527	-2.9
Priv.inv	-0.894	-3.525	-2.899	-3.563	-3.527	-2.9
Priv.con	-2.53	-3.525	-2.899	-3.571	-3.527	-2.9
CCI	-	-	-	-5.555	-3.527	-2.9
CPI	-	-	-	-5.257	-3.527	-2.9
Interest rate	-2.089	-3.525	-2.899	-5.347	-3.527	-2.9

Table B.8: Results from the Augmented Dicky-Fuller test Austria						
	Zeroth			First		
Variable	Test statistic	1% Critical Value	5% Critical Value	Test statistic	1% Critical Value	5% Critical Value
Govt.con	0.521	-3.525	-2.899	-8.339	-3.527	-2.9
Govt.inv	-0.453	-3.525	-2.899	-10.520	-3.527	-2.9
Govt.tot	-0.089	-3.525	-2.899	-8.727	-3.528	-2.9
Real GDP	-0.843	-3.525	-2.899	-7.390	-3.527	-2.9
Priv.inv	0.384	-3.525	-2.899	-4.453	-3.527	-2.9
Priv.con	-1.473	-3.525	-2.899	-3.93	-3.527	-2.9
CCI	-	-	-	-5.693	-3.527	-2.9
CPI	-	-	-	-5.497	-3.527	-2.9
Interest rate	-0.389	-3.525	-2.899	-7.792	-3.527	-2.9

Table B.9: Results from the Augmented Dicky-Fuller test Irland						
	Zeroth			First		
Variable	Test statistic	1% Critical Value	5% Critical Value	Test statistic	1% Critical Value	5% Critical Value
Govt.con	-2.079	-3.525	-2.899	-9.207	-3.528	-2.9
Govt.inv	-1.927	-3.525	-2.899	-11.731	-3.527	-2.9
Govt.tot	-1.41	-3.525	-2.899	-8.002	-3.528	-2.9
Real GDP	-0.368	-3.525	-2.899	-7.954	-3.527	-2.9
Priv.inv	-1.531	-3.525	-2.899	-4.877	-3.527	-2.9
Priv.con	-2.703	-3.525	-2.899	-3.04	-3.527	-2.9
CCI	-	-	-	-5.895	-3.527	-2.9
CPI	-	-	-	-4.472	-3.527	-2.9
Interest rate	-1.649	-3.525	-2.899	-7.792	-3.527	-2.9

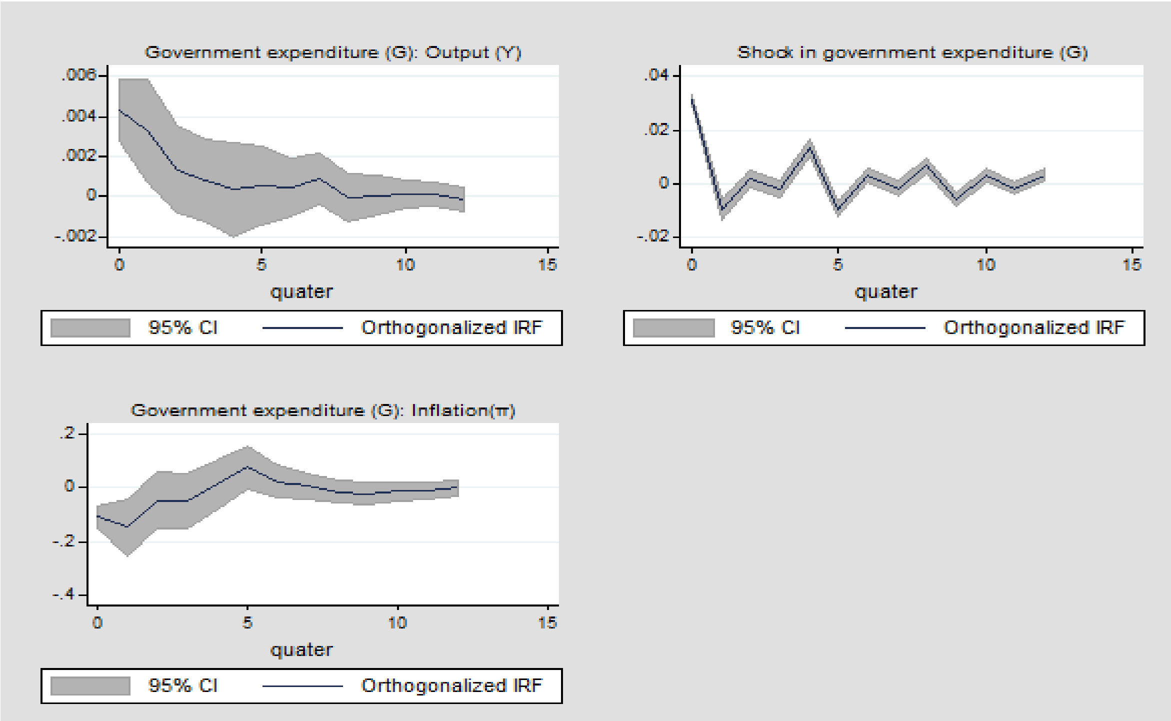

Figure B.1: The IRF graphs of benchmark model c that depict the responses of all variables of a shock in Total government expenditure for the whole period model.

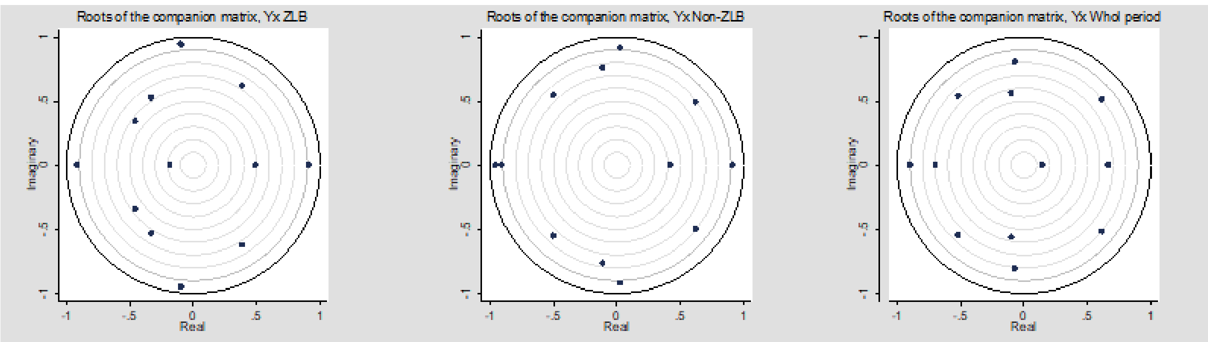

Figure B.2: Eigenvalue circles for the private output model

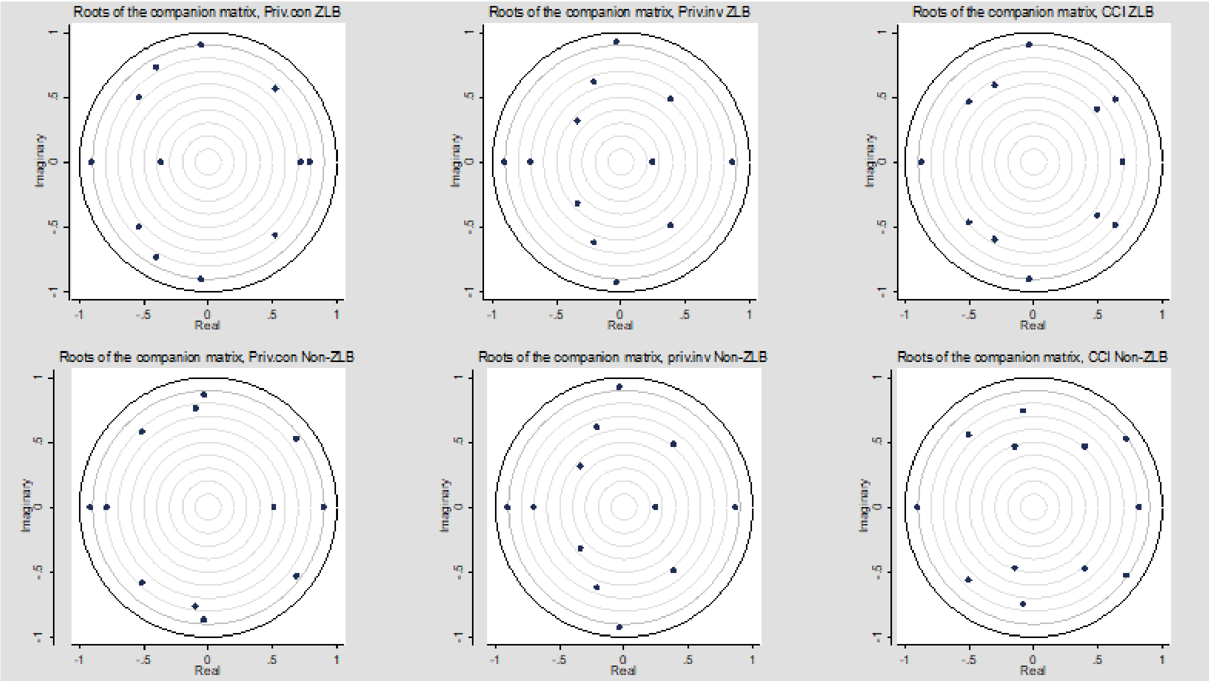

Figure B.3: Eigenvalue circles for the consumption, investment and CCI models

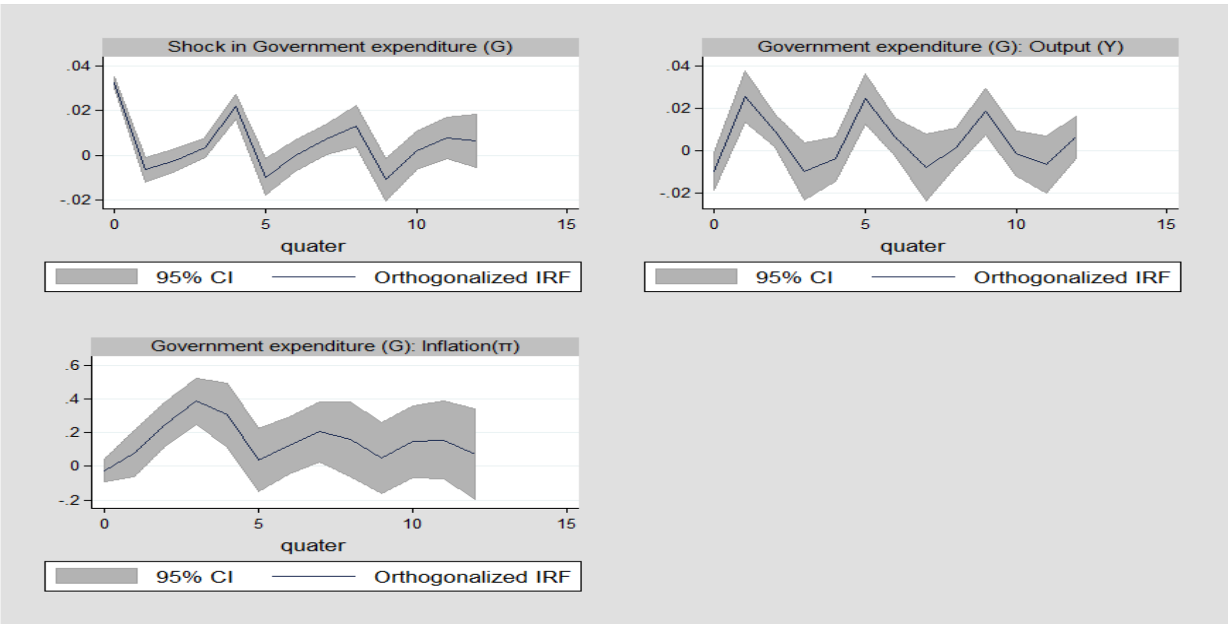

Figure B.4: The IRF graphs of the private output model that depict the responses of all variables of a shock in total government expenditure for the ZLB period model.

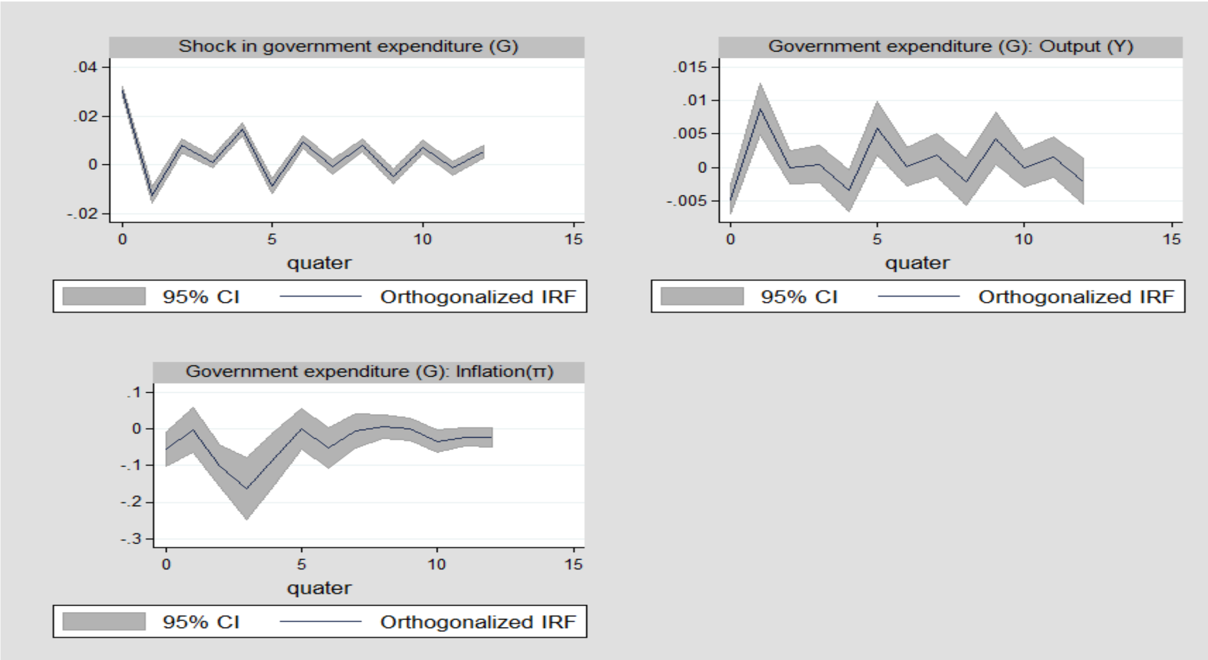

Figure B.5: The IRF graphs of the private output model that depict the responses of all variables of a shock in total government expenditure for the non-ZLB period model.

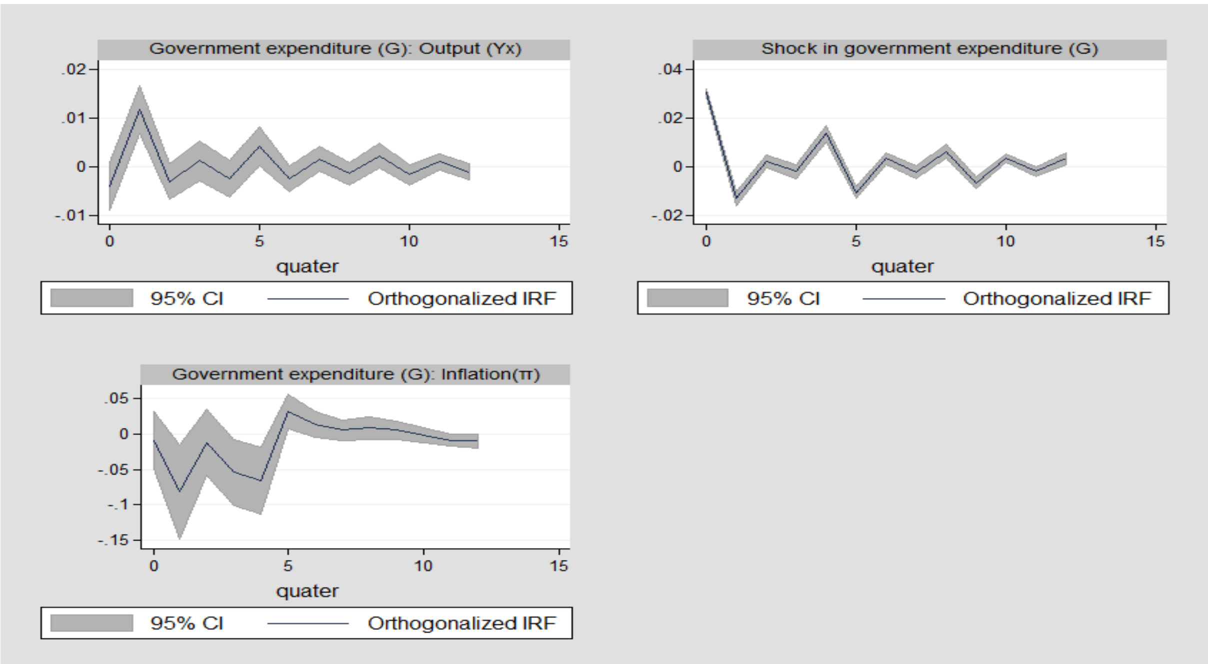

Figure B.6: The IRF graphs of the private output model that depict the responses of all variables of a shock in total government expenditure for the Whole period model.

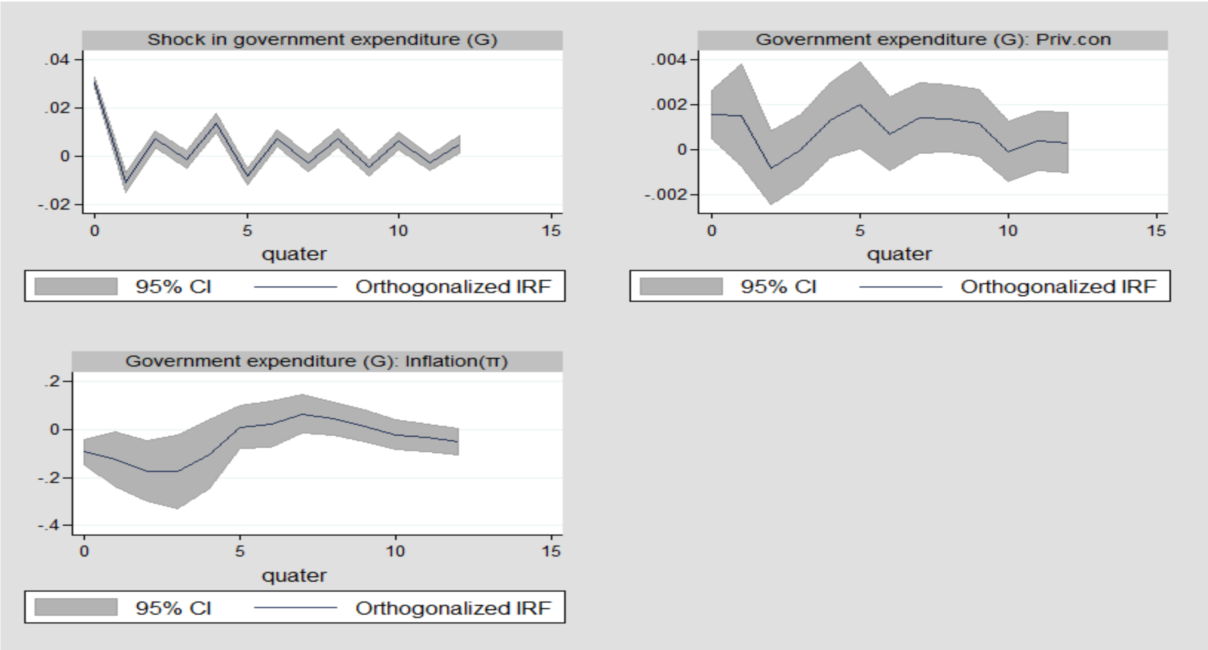

Figure B.7: The IRF graphs of the consumption that depict the responses of all variables of a shock in total government expenditure for the ZLB period model.

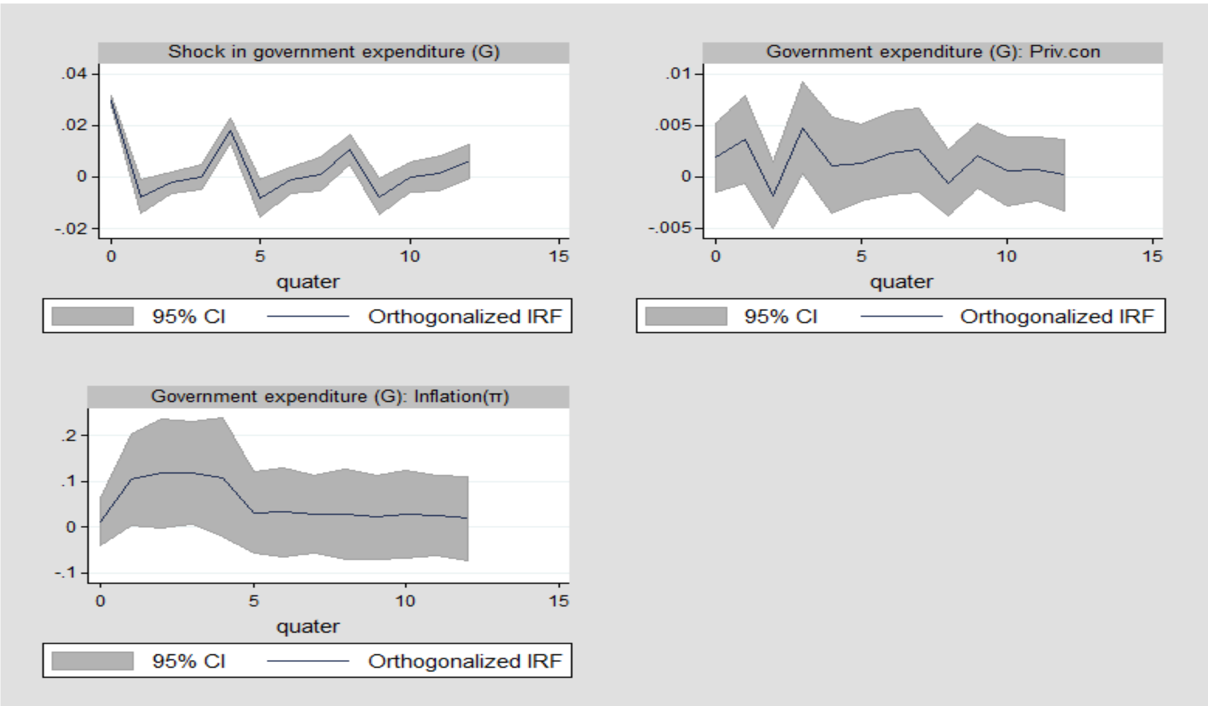

Figure B.8: The IRF graphs of the consumption that depict the responses of all variables of a shock in total government expenditure for the non-ZLB period model.

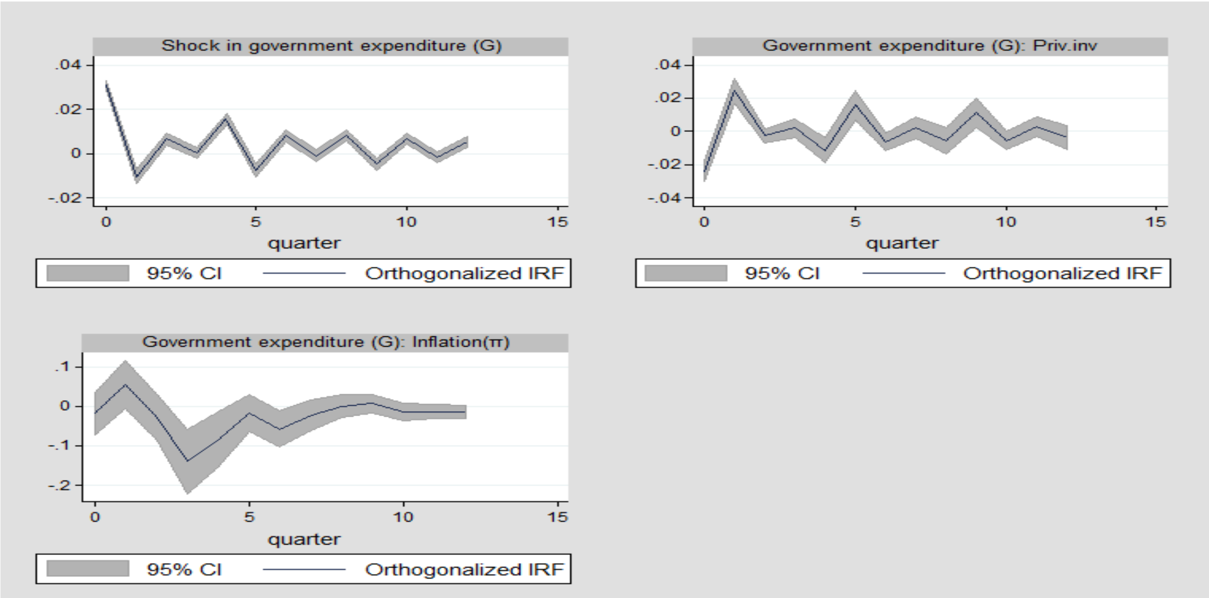

Figure B.9: The IRF graphs of the investment model that depict the responses of all variables of a shock in total government expenditure for the ZLB period model.

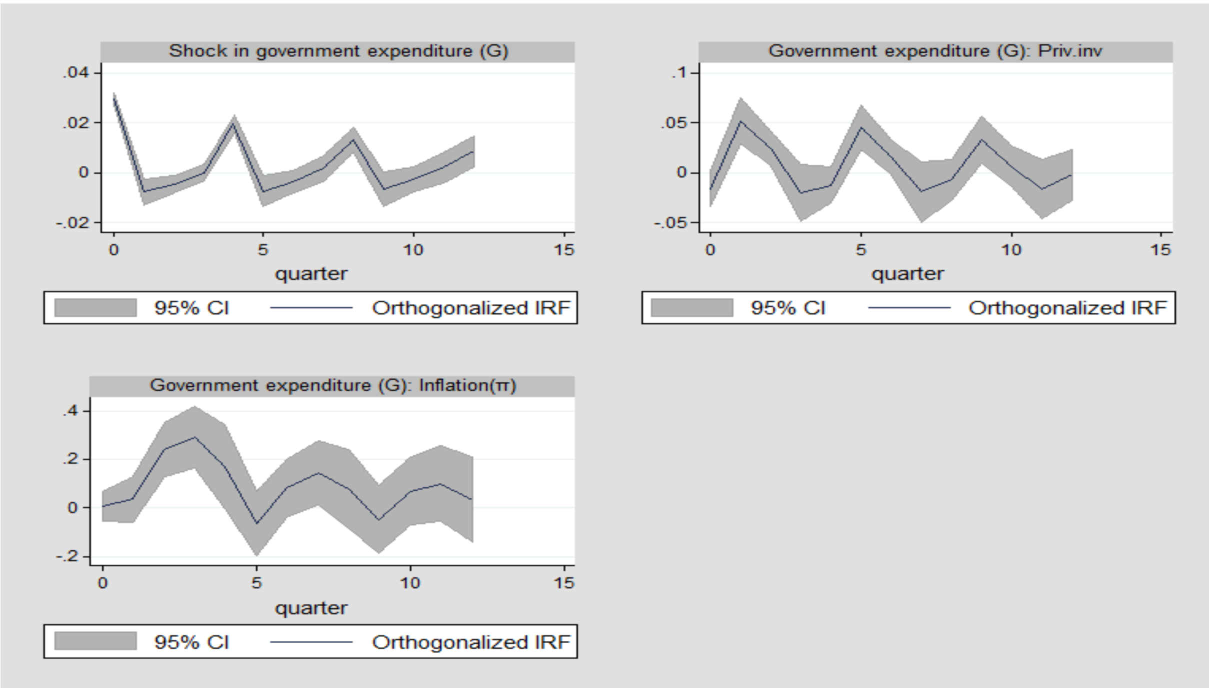

Figure B.10: The IRF graphs of the investment model that depict the responses of all variables of a shock in total government expenditure for the non-ZLB period model.

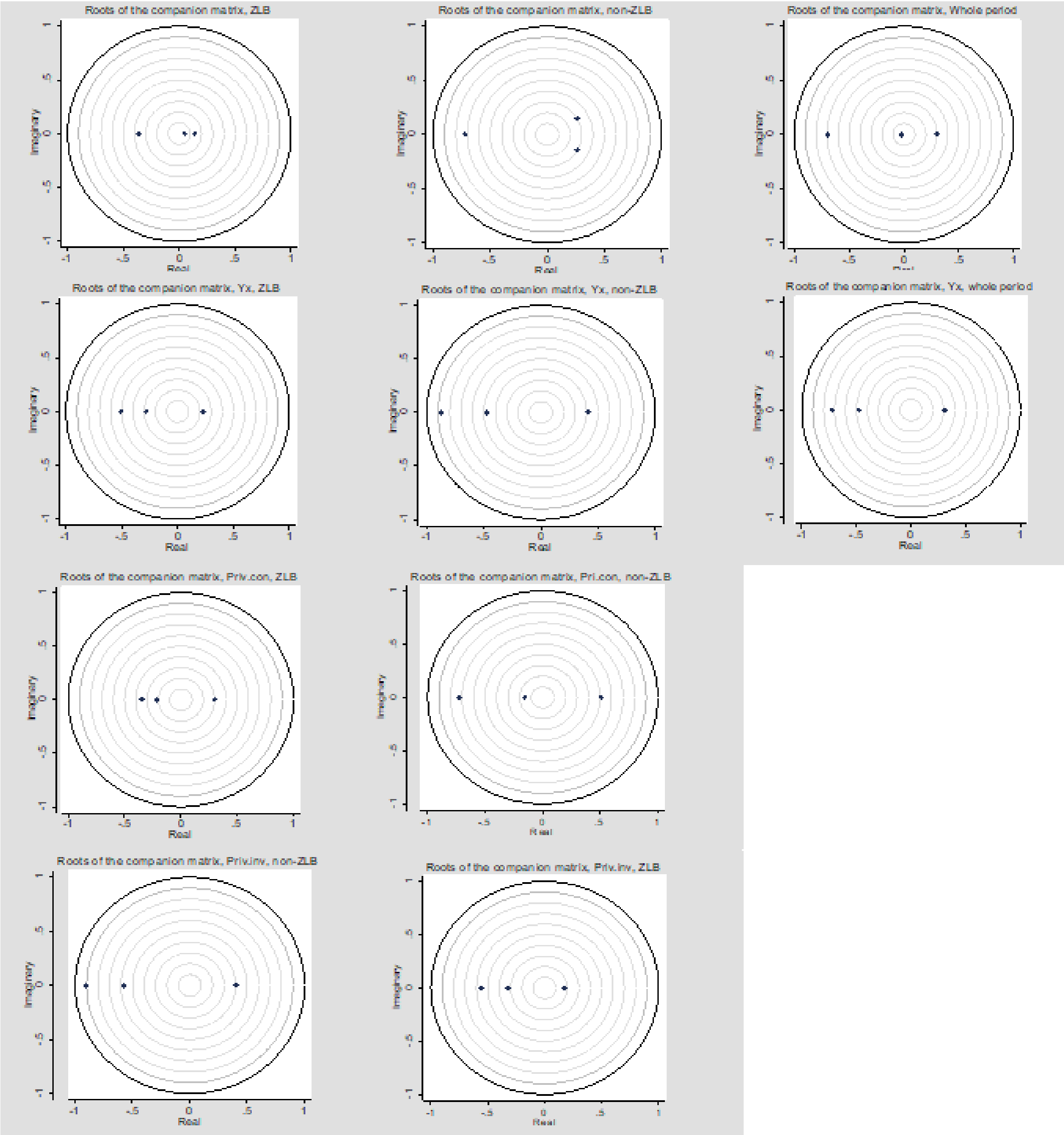

Figure B.11: Eigenvalue circles all lag sensitivity analysis models

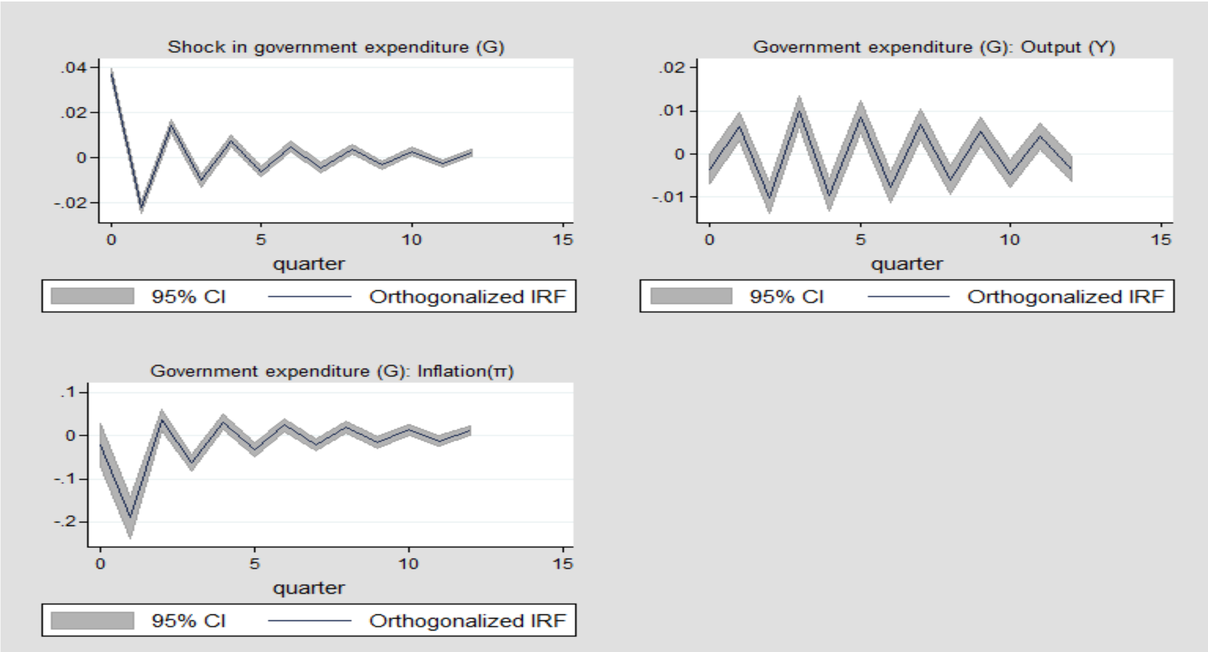

Figure B.12: The IRF graphs of benchmark model with one lag. Depicting the responses of all variables of a shock in total government expenditure for the ZLB period model.

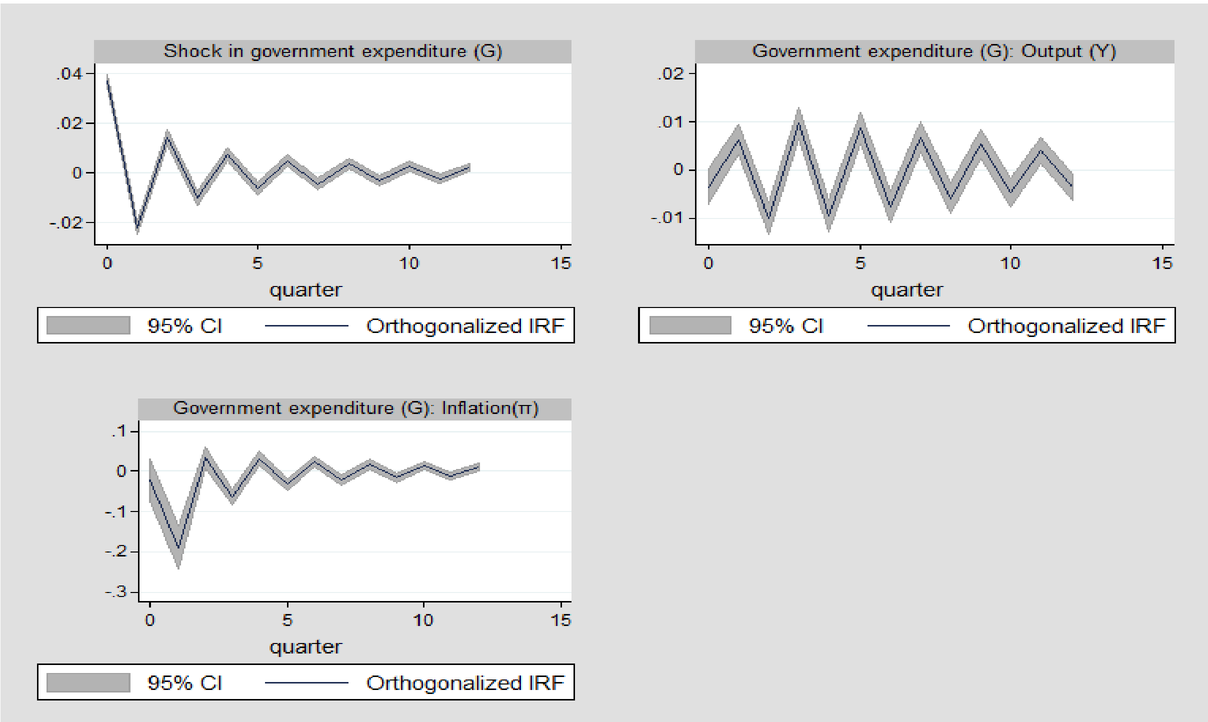

Figure B.13: The IRF graphs of benchmark model with one lag. Depicting the responses of all variables of a shock in total government expenditure for the non-ZLB period model.

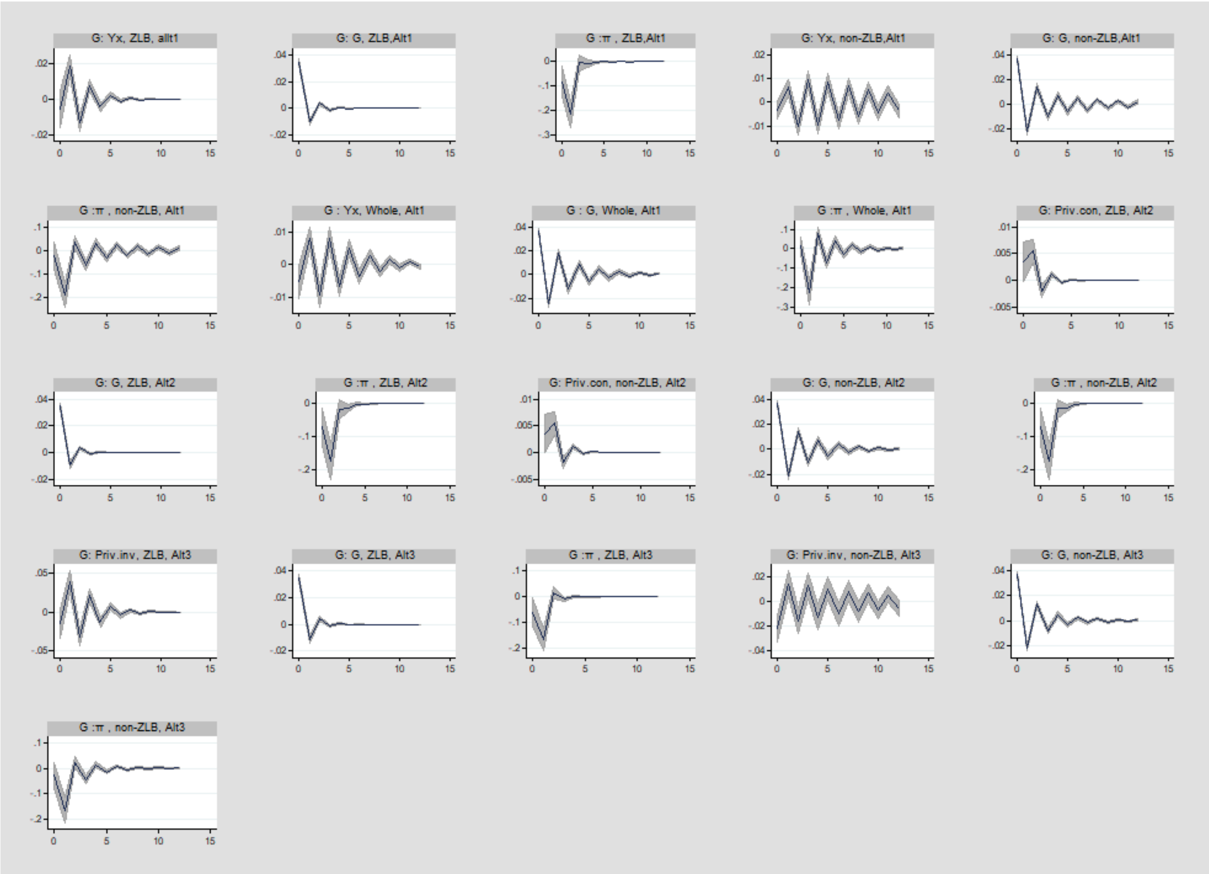

Figure B.14: The IRF graphs of all alternative models with one lag.

Table B.10 Results from Granger cauality test of the lag sensitivity analysis

Whole period	Equation	p-value		Equation	p-value
Govt.exp (G)	Output(Y)	0.000***	Output(Y)	Govt.exp (G)	0.822
Govt.exp (G)	Output(Yx)	0.000***	Output(Yx)	Govt.exp (G)	0.000***
Non ZLB					
Govt.exp (G)	Output(Y)	0.234	Output(Y)	Govt.exp (G)	0.000***
Govt.exp (G)	Output(Yx)	0.000***	Output(Yx)	Govt.exp (G)	0.000***
Govt.exp (G)	Priv.con	0.015**	Priv.con	Govt.exp (G)	0.000***
Govt.exp (G)	Priv.inv	0.086*	Priv.inv	Govt.exp (G)	0.000***
Govt.exp (G)	CCI	0.122	CCI	Govt.exp (G)	0,045**
ZLB					
Govt.exp (G)	Output(Y)	0.000***	Output(Y)	Govt.exp (G)	0.002***
Govt.exp (G)	Output(Yx)	0.000***	Output(Yx)	Govt.exp (G)	0.002***
Govt.exp (G)	Priv.con	0.000***	Priv.con	Govt.exp (G)	0.231
Govt.exp (G)	Priv.inv	0.000***	Priv.inv	Govt.exp (G)	0.187
Govt.exp (G)	CCI	0.004***	CCI	Govt.exp (G)	0.378

The statistical significance is denoted by ***, ** and * are 1 %, 5% and 10% -levles respectivly

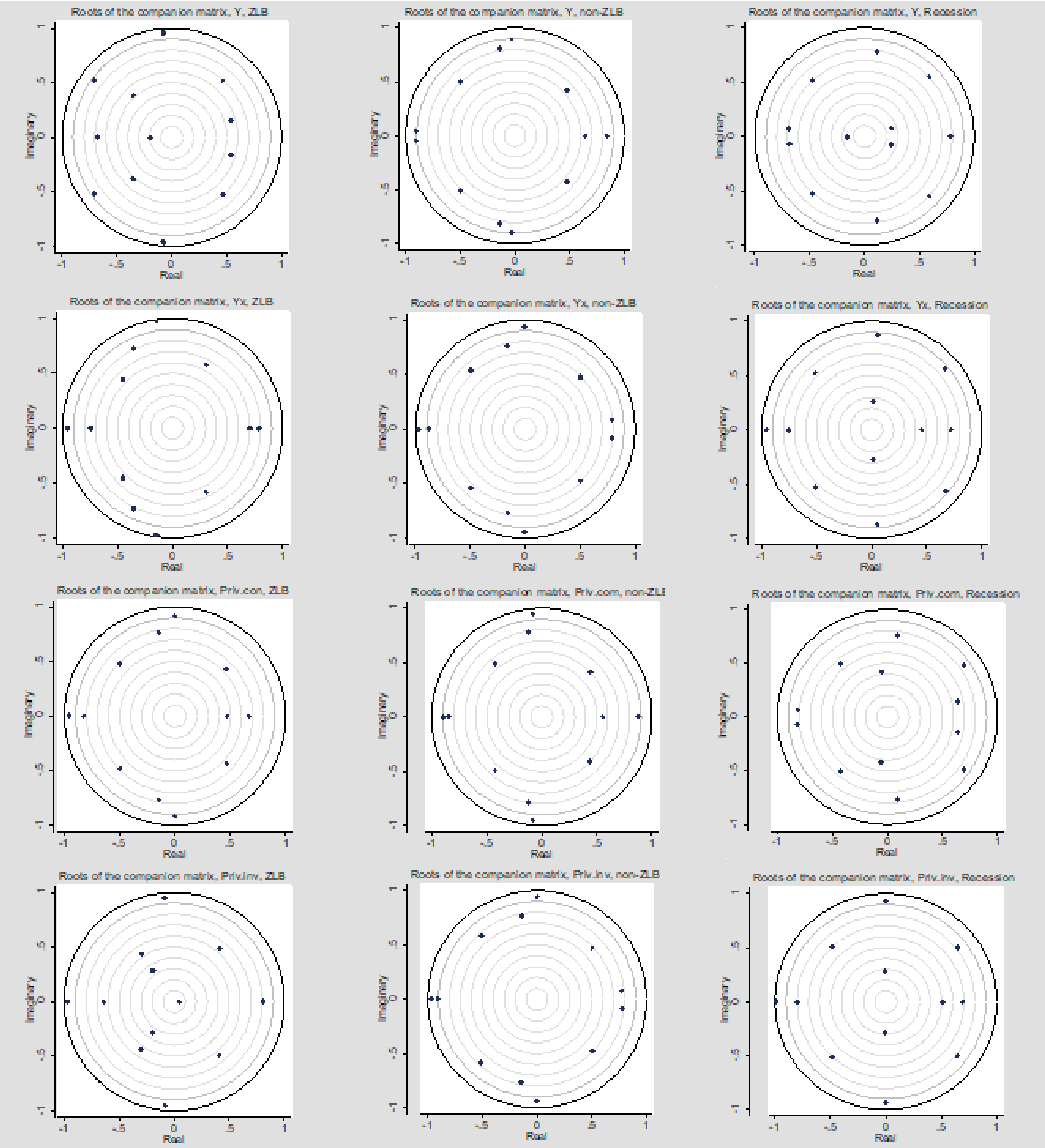

Figure B.15: Eigenvalue circles all period sensitivity analysis models

Figure B.16: The IRF graphs of benchmark model. Depicting the responses of all variables of a shock in total government expenditure for the ZLB period non-recession model.

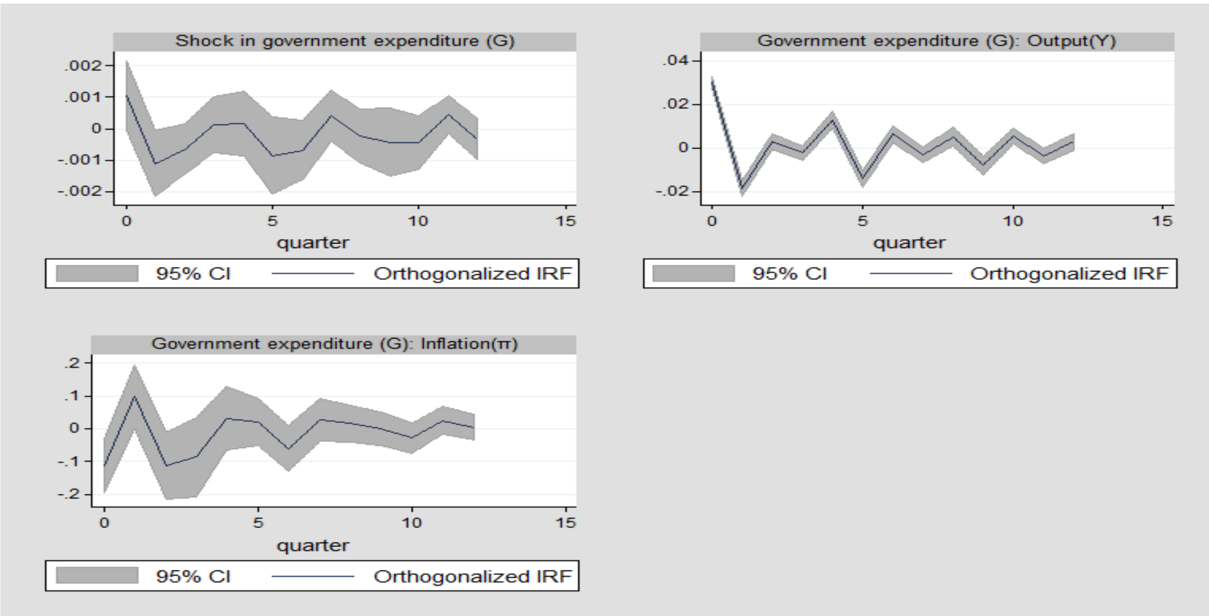

Figure B.17: The IRF graphs of benchmark model. Depicting the responses of all variables of a shock in total government expenditure for the non-ZLB period non-recession model.

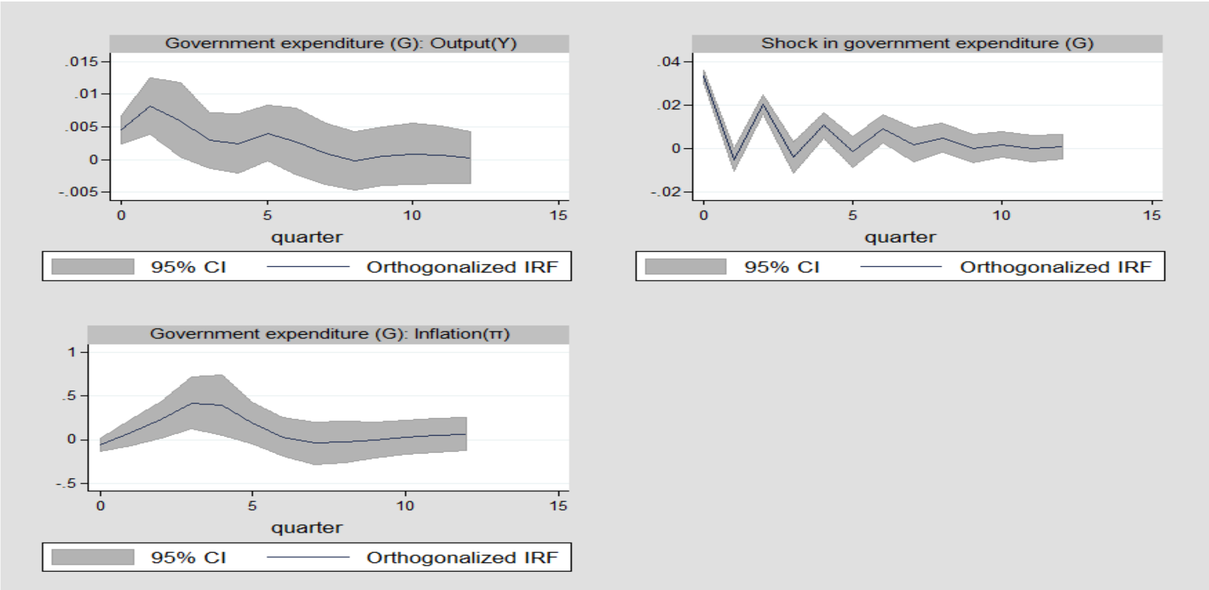

Figure B.18: The IRF graphs of benchmark model. Depicting the responses of all variables of a shock in total government expenditure for the recession model.

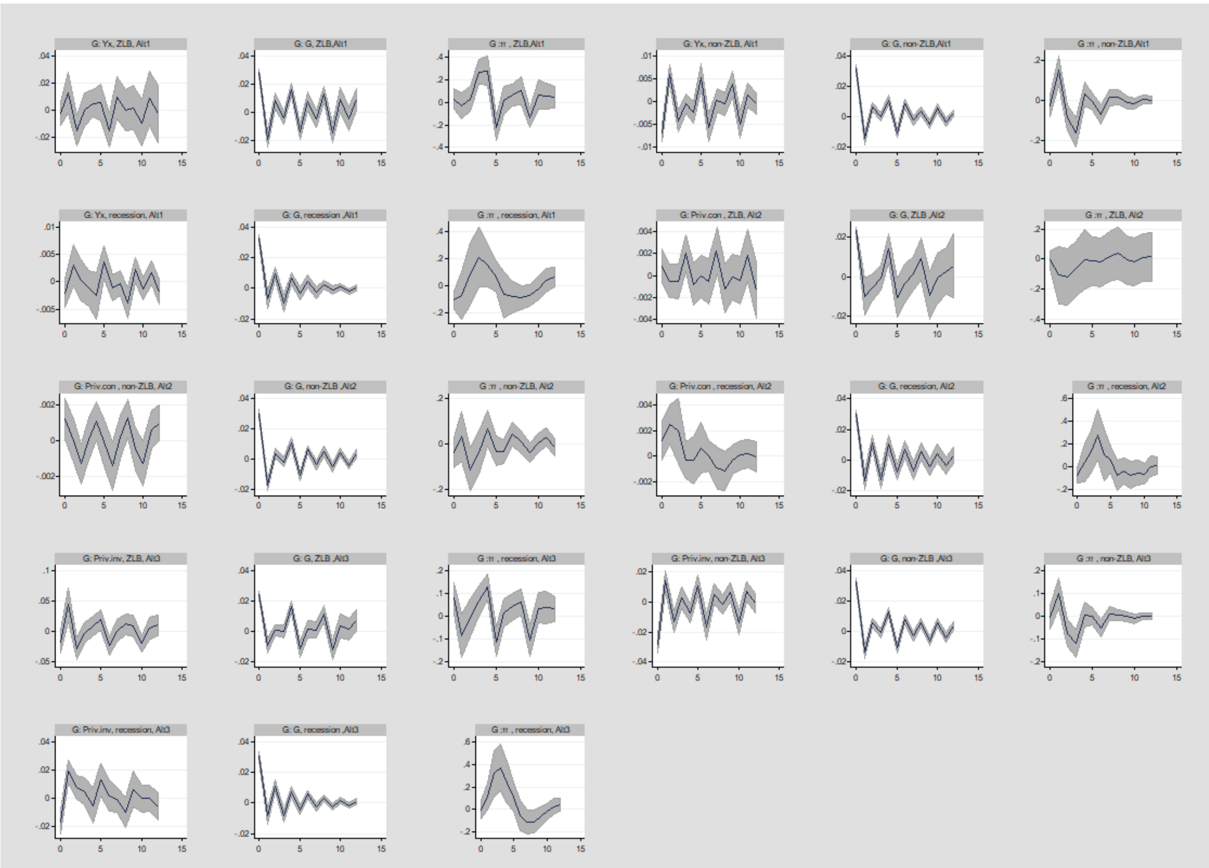

Figure B.19: The IRF graphs of all alternative models for the non-ZLB non-recession period, ZLB non-recession period and the recession period.

Table B.11 Results from Granger cauality test of the period sensitivity test					
Recession period (2008-2013)	Equation	p-value		Equation	p-value
Govt.exp (G)	Output(Y)	0.000***	Output(Y)	Govt.exp (G)	0.005***
Govt.exp (G)	Output(Yx)	0.000***	Output(Yx)	Govt.exp (G)	0.016**
Govt.exp (G)	Priv.con	0.000***	Priv.con	Govt.exp (G)	0.018**
Govt.exp (G)	Priv.inv	0.000***	Priv.inv	Govt.exp (G)	0.016**
Non ZLB (1999-2008)					
Govt.exp (G)	Output(Y)	0.000***	Output(Y)	Govt.exp (G)	0.000***
Govt.exp (G)	Output(Yx)	0.000***	Output(Yx)	Govt.exp (G)	0.000***
Govt.exp (G)	Priv.con	0.123	Priv.con	Govt.exp (G)	0.000***
Govt.exp (G)	Priv.inv	0.000***	Priv.inv	Govt.exp (G)	0.000***
Govt.exp (G)	CCI		CCI	Govt.exp (G)	
ZLB (2013-2019)					
Govt.exp (G)	Output(Y)	0.000***	Output(Y)	Govt.exp (G)	0.000***
Govt.exp (G)	Output(Yx)	0.000***	Output(Yx)	Govt.exp (G)	0.002***
Govt.exp (G)	Priv.con	0.000***	Priv.con	Govt.exp (G)	0.000***
Govt.exp (G)	Priv.inv	0.000***	Priv.inv	Govt.exp (G)	0.000***
Govt.exp (G)	CCI		CCI	Govt.exp (G)	
The statistical significance is denoted by ***, ** and * are 1 %, 5% and 10% -levles respectivly					

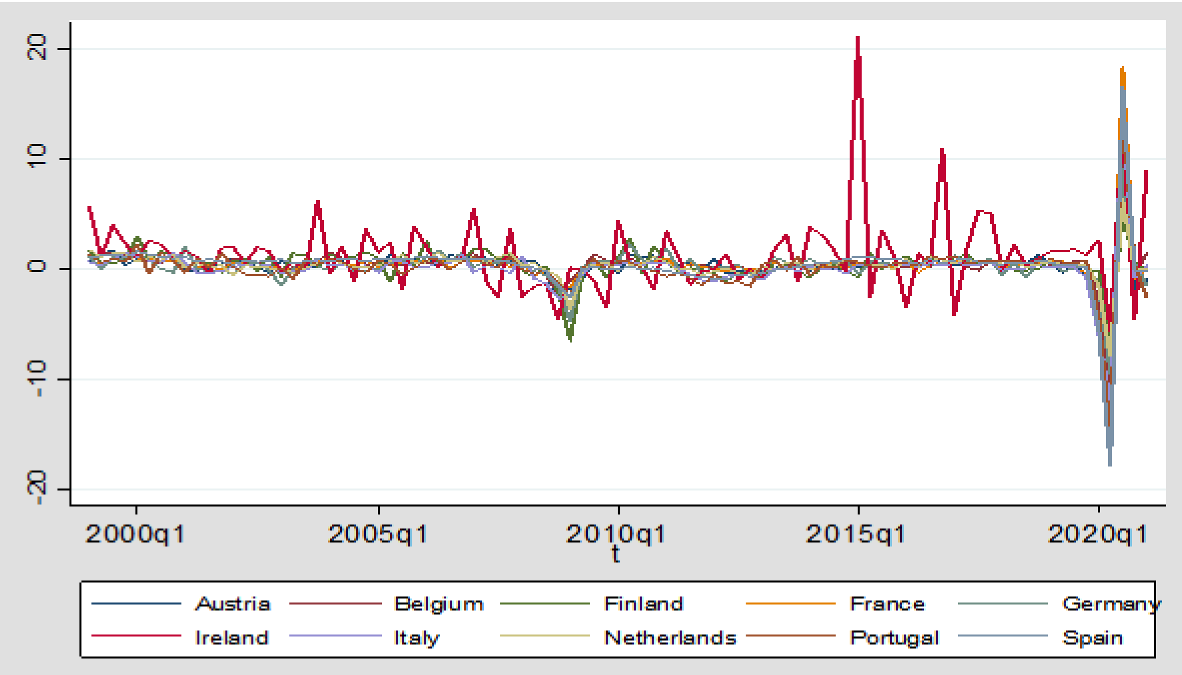

Figure B.20: The aggregated GDP growth of all the original EA countries