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The Effects of Fiscal Policy in a Small, Open Economy

A Structural VAR Analysis of Fiscal Shocks in Norway Employing Sign Restrictions

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Abstract

This thesis investigates how fiscal policy affects output (GDP) in a small, open economy. The analysis utilizes data on Mainland GDP, government spending and taxes in Norway from 1978 to 2017. In order to identify and estimate effects of exogenous fiscal shocks, we employ the sign restrictions approach in a Structural Vector Autogregression (SVAR) model. Our study represents a solid contribution to the literature of fiscal policy for two main reasons. First, we aim to provide empirical evidence on the effects of fiscal policy shocks in a small, open economy, for which the empirical literature is limited. Second, we conduct such an analysis through employing the sign restrictions approach which has not been widely applied thus far. Therefore, the study of Norway through such an approach provides a novel contribution to the suitability of the sign restrictions approach for small, open economies.

We find a positive effect on GDP from an increase in government spending, although the spending multiplier on GDP is weak and insignificant in the short run. Following a tax increase, GDP is negatively affected with a significant effect on impact. However, this negative effect is rather short-lived and becomes positive when including private consumption and investment in the model. Thus, we do not find a conclusive effect from tax shocks through the sign restrictions approach. We argue that the inconclusive findings in our analysis are likely due to a limited amount of identified fiscal shocks when employing sign restrictions. This is further supported when utilizing a more conventional recursive ordering approach for identification, through which we find a significantly positive effect on GDP following spending shocks. However, neither the sign restrictions or the conventional recursive approach provides conclusive evidence for tax shocks. Thus, we find that the analysis of net tax levels is an inadequate measure for tax effects in Norway, as tax changes in Norway predominantly focus on marginal tax rates and taxation structures.

Keywords – Fiscal policy, Macroeconomics, VAR, Sign restrictions

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1 Introduction

1.1 Motivation and Purpose

The purpose of this thesis is to investigate how fiscal policy affects total output (GDP) in a small, open economy through changes to government spending and taxes. Primarily, fiscal policy analysis studies the effects on GDP of fiscal shocks, which are changes to government spending and taxes that are independent from monetary policy and business cycle changes (Ramey, 2016). To this end, we apply a similar methodology and study the effects of fiscal shocks in Norway, as an interesting example of a small, open economy.

Several studies of fiscal shocks build on Blanchard and Perotti (2002), which estimates the dynamic effects of fiscal shocks on output in the United States through a Structural Vector Autoregression (SVAR) model. Blanchard and Perotti (2002) finds that positive government spending shocks have a positive effect on GDP, whereas positive tax shocks negatively affect GDP. The same effects are found for private consumption. Conversely, the study finds that both increases in spending and taxes have negative effects on private investment. Mountford and Uhlig (2009) expands the study utilizing the sign resrictions approach to identify fiscal shocks, which we follow in this thesis. Similar to Blanchard and Perotti (2002), the study finds that increased spending and reduced taxes positively affect GDP, estimating less significant effects on private consumption and investment.

Although the central theoretical frameworks on fiscal policy agree on the general effects on output of fiscal shocks, they offer diverging predictions of the effects on consumption and private investment. In addition, empirical findings are not entirely persuasive and offer mixed support to theoretical predictions. Hence, there is little consensus on the effect of fiscal shocks on the economy (Perotti et al., 2007). Traditionally, in contrast to monetary policy research, limited emphasis has been put on the study of fiscal policy. During the last decade, however, the amount of empirical analyses and academic discussions on fiscal policy effects has increased substantially with a stronger need for active fiscal policy (Thygesen et al., 2019). In consequence, there has been a gradual evolution in empirical methodologies investigating such relationships in recent years. For instance, the sign restrictions approach to identify fiscal shocks in a Structural Vector Autoregression

(SVAR) model aims to limit heavy theoretical assumptions and facilitate an agnostic approach to study fiscal policy (Mountford and Uhlig, 2009).

Following the Great Recession, many governments had to compensate for limited capacity in monetary policy due to low interest rates nearing the zero lower bound and damaged financial markets (IMF, 2017). In consequence, many economies had to rely on increased government spending to counteract an immense recession and implemented large fiscal stimuli, particularly in the form of financial sector guarantees and countercyclical policy acts. These stimuli packages were employed while tax revenues fell dramatically due to struggling private sectors, putting pressure on fiscal budgets that were already strained prior to the crisis. Thus, large national budget deficits accumulated that were hard to recover from, especially in countries experiencing a total collapse in commerce and the trade balance (Varoufakis, 2016). With high levels of public debt, many governments have had limited opportunity to conduct active fiscal policy, which has proved further challenging amidst the COVID-19 pandemic (Arezki and Devarajan, 2020).

In contrast, Norway is able to derive much of its countercyclical economic actions through fiscal policy due to the Government Pension Fund Global and its impact on national budget deficits. The Fund and the ability to stimulate demand through government spending has been essential for the bounce-back of Norwegian economic activity. This has been evident through the Great Recession and the oil crisis of 2014, in addition to the sharp economic downturn following the COVID-19 pandemic. As such, Norway serves as a relevant study of active fiscal policy in a small, open economy. Moreover, similar to other countries, Norway is facing a demographically demanding period, commonly called the Age Wave, where national budgetary challenges will be highly relevant issues in socioeconomic policy. Due to increased life expectancy, reduced child mortality and the 'baby-boomer' generation aging, Norway and other countries alike are facing a significant fall in the active labour force relative to the total population. This will likely cause reduced tax revenues per capita and increased negative taxes in the form of social transfers. In addition, a study of employment in Norway since the millennial change suggests that this development is further backed by automatization and limited flexibility in the labor market (Bhuller and Eika, 2019). Accordingly, changes to spending and tax patterns are reasonable to expect in the near future across several economies, including Norway. Hence, it is highly useful to investigate the effects of fiscal shocks in an economy such as Norway and assess implications for fiscal policy-making.

Our study represents a solid contribution to the literature of fiscal policy for two main reasons. First, we aim to provide empirical evidence on fiscal policy effects on a small, open economy. Predominantly, empirical literature of fiscal shocks thus far has studied the U.S. economy and other large economies such as Germany and the U.K. To this end, the study of effects in Norway contributes to limited empirical literature concerning the effects of government spending and tax shocks in small, open economies. To the best of our knowledge, there are few studies of fiscal shocks in Norway. With the exception of some master theses, only Asche and Kristjánsson (2019) investigates effects of Norwegian fiscal policy through a SVAR framework. Asche and Kristjánsson (2019) finds that government spending increases output, albeit with a smaller effect than in studies of other large economies. However, the study struggles to capture the effect of tax shocks in a sufficient manner. With this in mind, we apply a different approach to estimate the effects of government spending and tax shocks in the Norwegian economy.

Thus, our second major contribution is the employment of the sign restrictions approach, which has not been widely applied in fiscal policy. The approach aims to relieve the analysis of theoretical assumptions and as such "let the data speak for itself". Partly due to the computational complexity of applying the approach, most literature thus far has concentrated on the same U.S. data. Therefore, the study of Norway through such an approach provides an interesting contribution to the suitability of the sign restriction approach for small, open economies.

1.2 Research Question

To investigate the effects of fiscal policy in a small, open economy, we propose the following research question:

What are the dynamic effects of fiscal policy shocks on output in Norway?

We attempt to answer this question through a sign restrictions approach for identification of fiscal shocks in a Structural Vector Autoregression (SVAR) model.

1.3 Outline

The study is structured as follows. In **Section 2** we present an overview of the Norwegian fiscal framework, emphasizing the importance of the Government Pension Fund Global. **Section 3** presents a theoretical background concerning the effects of fiscal policy, while **Section 4** reviews empirical literature investigating these effects. **Section 5** presents our empirical strategy. **Section 6** gives a description of the collection and treatment of our data, while in **Section 7** we present the findings of our analysis. Finally, our concluding remarks are presented in **Section 8**.

2 Institutional Background

2.1 Characteristics of Norwegian Fiscal Policy

A definition commonly used by the Norwegian Ministry of Finance defines the role of fiscal policy as the sum of decisions that affects government spending and revenue, excluding sales and purchases of receivables (Johansen, 1965). Both volume and composition of spending and revenue is predominantly determined within the Norwegian Parliament through an annual national budget and a revised budget. In line with previous literature, government spending refers to the sum of total government consumption plus investment (Blanchard and Perotti, 2002). Government revenue or income is generally defined in related literature as the sum of all taxes less transfers and interest payments, which are regarded as negative taxes. For simplicity, we refer to government revenue as taxes or net taxes throughout this study, following e.g. Blanchard and Perotti (2002) and Mountford and Uhlig (2009).

Norwegian fiscal policy aims to finance a vast amount of common goods and welfare systems, in addition to accumulate sovereign wealth, without enforcing a perceived unfair tax burden on the population and without negatively affecting the remaining economy (NOU2015:9, 2015). With a comprehensive public sector regarding both government consumption and investment, Norway is a country in which fiscal policy has a substantial presence in the economy, as illustrated in Figure 2.1. Furthermore, amidst large national budget deficits across the world following the Great Recession, Norway is in a fortunate position regarding fiscal room for maneuver compared to myriad countries. This is evident in Figure 2.1, where Norway is second only to Luxembourg with respect to government spending and revenue.

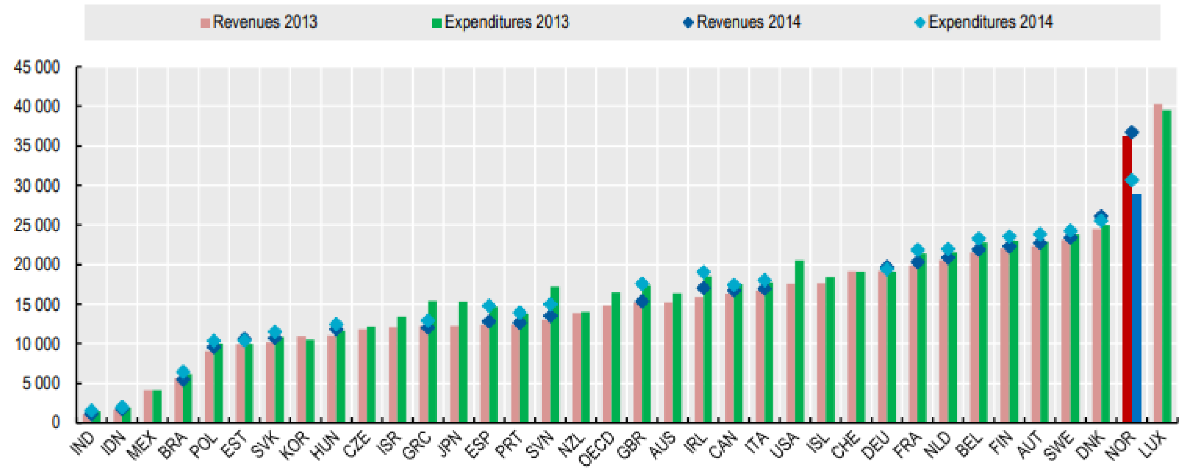

Figure 2.1: General Government Revenues and Expenditures Per Capita in US dollars, Current Prices and PPPs. The red and blue columns represent 2013 revenues and expenditures in Norway, respectively. Retrieved from the OECD Factbook 2015-2016 (OECD, 2016).

The particularities of the Norwegian Fiscal Framework further act as a countercyclical measure to offset business cycle fluctuations. As such, Norwegian fiscal policy has been important to “lean against the wind” in booms and stimulate activity in busts (Gjedrem, 2019). Consequently, it serves as a highly interesting case study for fiscal policy research. In this Norwegian fiscal framework, we will briefly review three key elements of fiscal and monetary policy which interplay, as illustrated in figure 2.2. All government revenues resulting from petroleum extraction are transferred in their entirety to (1) the Sovereign Wealth Fund, from which revenues subject to (2) a fiscal rule are used to cover national budget deficits. In addition, (3) a stable inflation target and a flexible exchange rate regime operated through the Central Bank supports stabilization, aiming to smooth cycles in production and employment (Gjedrem, 2019).

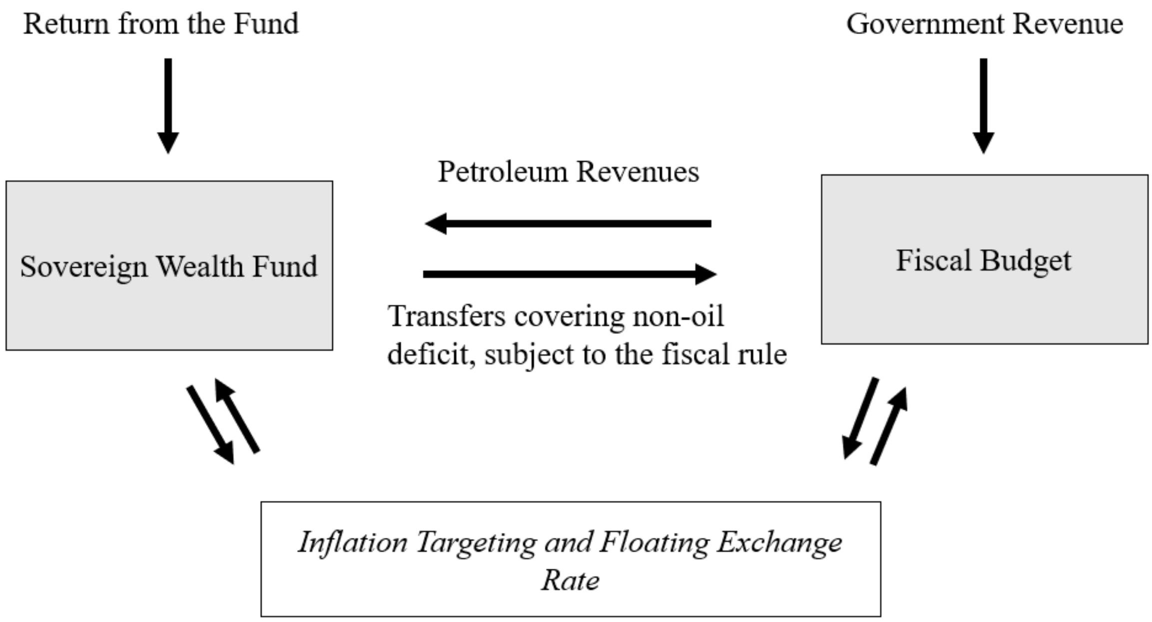

Figure 2.2: The Sovereign Wealth Fund Mechanism (Gjedrem, 2019).

2.2 The Sovereign Wealth Fund

In the discussion on Norwegian fiscal policy, a key element is government revenue related to petroleum extraction, which is typically large and often fluctuating subject to supply and demand shocks (NOU2015:9, 2015). Examples of sudden large changes to petroleum revenues include the sharp price falls after the 1973 and 2020 OPEC disagreements, as well as the 2014 oil crisis which affected firms in regions heavily dependent on industries related to petroleum extraction (Grytten and Hunnes, 2016). Therefore, all petroleum-related government revenues since 1992 have been directly transferred to the Government Pension Fund Global, commonly known as the Sovereign Wealth Fund, accumulating government revenues from petroleum extraction for all future generations. One objective of creating the fund was to limit fluctuating fiscal policy, as the room for maneuver would vary greatly in relation to volatile petroleum prices when these revenues were directly covering national budget deficits. This presented a challenge for long-term planning of welfare development and infrastructure, and could additionally cause a procyclical fiscal policy regime in which decisions are expansive in economic booms and contractive in busts (NOU2015:9, 2015). The financial assets of the fund was placed exclusively abroad in order to function as a diversified stabilization tool, in which a countercyclical exchange rate balances out the funds worth measured in Norwegian kroner.

2.3 The Fiscal Rule

Furthermore, following the introduction of the fiscal rule in 2001, the revenues covering fiscal budget deficits are solely based on the expected real returns of the fund. Initially, the Norwegian fiscal rule aimed towards a balanced withdrawal of petroleum-related revenue at an expected 4% real return rate, which was later reduced to 3% after recommendations of the 'Thøgersen-committee' (NOU2015:9, 2015). Thus, a steady accumulation of Sovereign wealth in the fund has been accompanied by a gradual increase in the spending of petroleum revenues. At the same time, Norway is in a unique position through constant withdrawals of the returns of financial assets, as opposed to paying interest on annual budget deficits which many countries are presently forced to do (Varoufakis, 2016). Hence, Norwegian fiscal policy is protected to a larger extent against increasing future budget deficits and periods of forced contractive policy-making. Importantly, however, the steady increase in the budget deficit has not been entirely automatic as the fiscal rule characterizes fiscal policy as a tool for the stabilization of total production and employment.

2.4 Inflation Targeting and Floating Exchange Rate

After a long period of large business cycle fluctuations and policy-making that amplified these fluctuations, a fixed monetary policy regime had proved troublesome (Corsetti et al., 2016). Based on these experiences, particularly economic crises in the 70s and 90s, monetary policy shifted towards inflation targeting. Although officially announced by the Norwegian Ministry of Finance in 2001, informal implementation of inflation targeting started in June 1999 with an aim of 2 percent inflation over time (Corsetti et al., 2016). Since then, the mandate for the Central Bank has been to stabilize the trajectory of the Norwegian krone and corresponding expectations of future exchange rate developments. Moreover, the Bank is to interplay with fiscal policy in supporting a stable development in output and employment. The inflation target is currently followed through an operational target of an annual consumer price inflation of approximately 2 percent.

The floating exchange rate of the Norwegian krone is further affected by the fiscal policy transmission mechanism through changes to aggregate demand. Through this transmission mechanism, fiscal policy influences the domestic interest rate and inflation, as well as expectations of inflation and currency developments (Gjedrem, 2019). As a small, open economy that largely depends on trade, the floating exchange rate acts as a stabilization tool in depreciating the currency in economic downturns. As the value of Norwegian goods and wages measured in kroner become relatively more competitive domestically and abroad, this floating exchange rate somewhat offsets business cycle fluctuations.

With this framework in mind, we aim to analyse the effects of exogenous fiscal changes on the Norwegian economy. The majority of fiscal policy literature discusses the direction and magnitude of fiscal multipliers. Following the definition in previous Norwegian literature, we refer to fiscal multipliers as the stimulating effects on macroeconomic variables (predominantly GDP) resulting from a given change in a fiscal policy measure (Boug et al., 2017). Therefore, our presentation of related literature is structured around the theoretical predictions and empirical estimates of fiscal multipliers.

3 Theoretical Literature

3.1 Fiscal Multipliers

Predominantly, previous literature analyses the dynamic effects of fiscal multipliers through a time horizon. Furthermore, *peak multipliers* are widely used to compare results following Blanchard and Perotti (2002). Peak multipliers represent the maximum fiscal multipliers across said time horizon following a fiscal shock and are calculated as follows:

$$Fiscal\ multiplier\ = \frac{\Delta Y_{max}}{\Delta X_0} \tag{3.1}$$

In Equation 3.1, ΔY_{max} represents the maximum change in GDP while $\Delta X_0 \in (G_0, T_0)$, represents the initial change in government spending or net taxes. The modeling and estimation of these effects on output diverge substantially both in underlying theoretical assumptions and identification methods of fiscal shocks. First, economic activity is differently influenced depending on the characteristics of the fiscal change in question. For instance, increased military spending and increased funding for employment in healthcare, though equal in magnitude in the national budget, will produce different fiscal multipliers on an economy. Second, the sign and size of fiscal multipliers are highly sensitive to the underlying theoretical assumptions of the model through which they are assessed. A central divergence in this regard is whether or not agents are forward-looking, an assumption founded in microeconomic theory. Models that ignore the forward-looking behavior of rational agents, do not take into account the intertemporal budget constraints facing consumers, firms and governments alike. Therefore, expected future changes in income and output do not affect behavior in the current period, contrary to forward-looking models where agents with rational expectations incorporate future implications (Hebous, 2011).

3.2 Standard Keynesian Models

Crucial assumptions of Keynesian theory, as described in John Maynard Keynes' *General Theory* (1936), are that prices are sticky and that consumption is a constant fraction of net income in the current period (Hebous, 2011). As such, GDP in Keynesian models is demand-determined in the short run and subject to effects from domestic fiscal policy.

Standard Keynesian theory predicts that increased government spending stimulates economic activity through an accelerator effect and raises output, all else equal. In turn, this growth in production increases the disposable income of households and raises private consumption. Hence, expansive fiscal spending yields an increase in output, total investment and consumption. As prices in Keynesian models are nominally rigid and demand for money depends on income, increased output causes a raise in the domestic interest rate. This interest rate hike may prevail over the accelerator effect and lead to a crowding out of private investment, depending on the propensity of private investment to income and the specific change in the interest rate (Gaber et al., 2013). In contrast, an increase in government revenue through tax raises has a negative effect on output. Increased taxes reduce disposable income, causing a contraction in private consumption and in turn aggregate demand and output. However, in the traditional Keynesian model, taxes affect households only through a negative wealth effect in the current period and are therefore considerably smaller than spending multipliers in such models (Hebous, 2011).

Nevertheless, theoretical literature is increasingly built on Dynamic Stochastic General Equilibrium (DSGE) models which incorporate forward-looking agents with rational expectations, and consequently predict different multipliers.

3.3 DSGE Models

DSGE models incorporate intertemporal aggregate relations where consumers maximise lifetime expected utility following the permanent income hypothesis of Friedman (1957), while firms maximise profit constrained by available technology. Furthermore, the government operates within a budget constraint subject to an intertemporal fiscal rule. Two essential DSGE models, namely Neoclassical models and New-Keynesian (NK) models, primarily differ in two assumptions. Neoclassical models assume perfect competition and flexible prices, whereas NK models combine Keynesian assumptions of nominally rigid prices and imperfect competition with forward-looking agents.

Neoclassical Models

Similar to Keynesian predictions, Neoclassical models predict positive multipliers of spending shocks and negative (distortionary) multipliers from tax shocks, although differing in underlying mechanisms (Ramey, 2019). In contrast to the Keynesian world, forward-looking consumers understand that increased government spending in the current period must be debt-financed through increased future taxes. Therefore, expansive fiscal policy measures yield a negative wealth effect through an increase in the present value of future tax liabilities. Subject to Ricardian equivalence, households save due to a negative effect on permanent income rather than consume to the extent that standard Keynesian models predict (Hebous, 2011). As government spending extracts resources from the private sector in the neoclassical world, forward-looking consumers compensate for a reduction in expected future income by increasing their labour supply which increases production. This increase in hours worked causes investment to increase as the higher steady state of hours worked requires larger investments to accumulate capital stock. Consequently, expansive fiscal policy causes private consumption to decline whilst investment and output increases. Similarly, due to this large effect on permanent income, distortionary tax increases can yield large negative multipliers on the economy (Ramey, 2019).

New-Keynesian DSGE Models

The New-Keynesian DSGE framework incorporates the neoclassical assumptions of forward-looking agents combined with Keynesian elements of monopolistic competition and sticky prices (Hebous, 2011). Similar to neoclassical models, government spending in NK-DSGE models yield increased output and reduced consumption. Due to the intertemporal negative wealth effect, forward-looking consumers reduce consumption and increase labour supply, boosting output. However, due to the assumptions of sticky prices and monopolistic competition, the increase in labour demand caused by higher production balances out the raise in labour supply. Hence, real wages increase after expansive fiscal policy rather than decrease as in the neoclassical models (Pappa, 2009). Moreover, due to price rigidities, NK-DSGE models predict a crowding out of private investment as the interest rate rises due to increased output. Nevertheless, Christiano et al. (2011) show that in the case of a strictly binding zero bound on nominal interest rate, the expansive fiscal multipliers effect on output causes expected inflation to increase. In turn, this causes a decline in the real interest rate in the economy and in such an economy, government spending multipliers are relatively large. Similar to neoclassical models, due to the large importance of an intertemporal wealth effect, distortionary tax changes can yield large negative effects on output. In summary, expansive fiscal policy in NK-DSGE models yield similar predictions to Keynesian theory with respect to increased output and reduced private investment, whilst agreeing with neoclassical models on a negative effect on private consumption.

Most empirical literature has aimed to qualitatively assess the predictions of these models and estimate multipliers on the economy, primarily diverging in the identification of fiscal shocks.

4 Empirical Literature

4.1 Fiscal Shocks

Predominantly, studies of fiscal policy attempt to estimate multipliers derived from fiscal shocks. There is essentially no single characterization of a fiscal policy shock. Rather, fiscal policy captures a wide array of policy actions, encompassing countless different tax structures and various types of government spending. In empirical literature, these fiscal shocks are defined as primitive, exogenous and/or unanticipated changes to a fiscal variable (Ramey, 2016). Hence, identified fiscal shocks have to represent unanticipated movements that are orthogonal to other exogenous shocks and other endogenous variables in the model, both current and lagged. In contrast, fiscal policy changes that occur in response to business cycle movements are characterized as automatic stabilizers and discretionary fiscal policy, respectively. The former comprises already established features of the government spending and tax systems that automatically respond to business cycle fluctuations, whereas the latter encompasses all policy measures enacted reactively to such fluctuations. Thus, truly exogenous fiscal shocks are uncorrelated to the state of the economy, for instance a sudden change in income tax after a shift in political power or substantial government spending in the outbreak of war (Ramey, 2016).

4.2 Identification of Fiscal Shocks

Structural Vector Autoregression (SVAR) models have become the primary tool to estimate multipliers of fiscal shocks since the formative work of Sims (1980). In a response to computational models structured around heavy theoretical assumptions, SVAR models aim to let the data speak for itself. In a multivariate model where connected time series variables are interdependent, one can disentangle the structural relationships between variables and infer economic meaning to structural shocks.

Though predominantly utilized to estimate effects of monetary policy, the use of SVAR models has grown gradually through the aforementioned renaissance in fiscal research (Ramey, 2019). Indeed, Blanchard and Perotti (2002) argues that the intrinsic mechanisms of fiscal policy make the SVAR approach better suited for assessing fiscal shocks than monetary ones. First, whereas monetary policy frequently acts in correlation with business cycle fluctuations, output stabilization is rarely the main driver of fiscal policy changes. Second, as opposed to monetary policy, the slow process of fiscal policy decision-making and implementation implies that there are negligible fiscal responses to contemporaneous output changes. Hence, we can compute estimates of the automatic effects of output movements, and by implication decouple and estimate truly exogenous fiscal shocks (Blanchard and Perotti, 2002).

Although straightforward in principle, the identification of these exogenous fiscal shocks, i.e. isolating exogenous movements in fiscal variables from endogenous ones, is empirically challenging. Moreover, the methodology utilized for identification can produce large variation in the magnitude of fiscal multipliers, as well as some qualitative divergence (Caldara and Kamps, 2017). Several studies since Sims (1980) have argued for different strategies, and the next section briefly describes three widely used approaches to identify fiscal shocks.

The Blanchard-Perotti Approach

Blanchard and Perotti (2002) provides a seminal contribution to fiscal policy research building upon the work of Sims (1980), identifying both government spending and tax shocks. Essentially, the study employs institutional information and externally computed estimates for structural relationships to calculate and restrict contemporaneous responses among the endogenous variables.

The method assumes that all unanticipated fluctuations in spending and taxes are caused by either (1) automatic stabilizers, (2) discretionary responses to business cycle fluctuations or (3) truly exogenous fiscal shocks, which are the shocks subject to analysis. Furthermore, due to the discussed lags in policy implementation, Blanchard and Perotti (2002) assumes that there is no discretionary response within the current period, restricting the contemporaneous relationship to zero. Thus, economic assumptions and institutional information are utilized to restrict contemporaneous relationships between the variables. Whereas these restrictions are strictly limited to zero in the recursive ordering of Sims (1980), Blanchard and Perotti (2002) considers invalidations of the zero restrictions caused by factors such as forward-looking behavior or asymmetrical information. For instance, through an external calculation of the elasticity of taxes to movements in GDP, they identify structural relationships and by implication identify exogenous tax shocks.

Although providing a solid basis for further fiscal policy research and improvements in identification methodology, the Blanchard-Perotti approach has faced certain criticism. First, the method struggles to account for anticipation effects of fiscal policy and anticipated responses prior to the implementation of a fiscal policy change may cause a bias. Second, related literature argue that strong economic assumptions imposed by the approach might direct the model towards certain results (Mountford and Uhlig, 2009). Finally, the estimates of tax multipliers are highly sensitive to the calculation of tax elasticity to output, which has been questioned as an inappropriate measure to estimate structural tax relationships (Caldara and Kamps, 2008).

The Narrative Approach

In contrast, the narrative approach aims to identify exogenous shocks by reviewing large amounts of historical documents and announcements on fiscal policy changes (Romer and Romer, 2010). The approach utilizes such information to construct a rich time series to describe the underlying reasons and quantities of changes to fiscal variables (Ramey, 2016). Typically, information on military spending and legislative tax changes has been applied to construct a series for analysis. Through such an assessment, the aim is to identify changes to spending and/or taxes that are unrelated to other factors which either affect current or future economic development (Ramey, 2016). These changes are treated as exogenous and thus constitute the fiscal shocks.

Studies that apply the narrative approach for identification tend to estimate smaller multipliers in the short run and much higher long-term multipliers (Ramey, 2019), illustrating the significance of identification strategy. Moreover, as opposed to other SVAR models, the narrative approach is more able to account for anticipation effects, which has been a general challenge in SVAR literature. However, some narrative-based research has faced criticism for assuming that the approach alone secures exogeneity in identification, which is not necessarily the case (Ramey, 2016). In addition, the approach may falsely define shocks of one character to hold for all subsequent shocks, and lastly it is time and resource consuming.

The Sign Restrictions Approach

Finally, a central identification method of fiscal policy shocks is the sign restrictions approach pioneered by Faust (1998) and Uhlig (1997), which was adapted to fiscal policy research by Mountford and Uhlig (2009). In contrast to the Blanchard-Perotti method, the sign restrictions approach impose assumptions only on the sign of the responses of endogenous variables following a fiscal shock. As we utilize this approach, it is explained in detail in our empirical strategy. The strategy was developed in response to the conventional approaches, which Uhlig (2005) argues are too restricted by theoretical assumptions. In order to estimate the true values of these effects, studies leveraging sign restrictions aim to limit assumptions and be agnostic with respect to contemporaneous relationships. Similarly, where conventional methods rely on a strict chain of causation within the model, the sign restrictions approach is less restrictive and all variables are estimated simultaneously in the system of equations.

As the scope of this paper is limited, we have restricted the overview of identification methods to the three main approaches. Ramey (2016) provides a detailed description of several other identification methods and the results of these. Next, we will provide a brief synthesis of empirical findings utilizing the above approaches.

4.3 Empirical Results

Empirical studies of fiscal shocks have mainly investigated the direction and size of the effects on output. With respect to the qualitative direction, one intends to assess whether effects of fiscal policy shocks are empirically consistent with theoretical predictions. Concerning the quantitative size, literature aims to estimate the fiscal multipliers of government spending and tax shocks, respectively. When discussing ranges of spending or tax multipliers in empirical results, we refer to the variation of multipliers throughout a time horizon (typically 20 or 25 quarters). Impact multipliers represent the initial effect on output, referring to the dollar change in GDP in the first quarter following a one-dollar spending increase. Meanwhile, the aforementioned peak multipliers represent the maximum effect in dollars found throughout the horizon relative to the initial fiscal shock.

Government Spending Shocks

Generally, the empirical literature estimating fiscal policy shocks finds qualitative results which are consistent with theoretical predictions of New-Keynesian DSGE models regarding output and investment: a positive government spending shock yields a rise in GDP and consumption, whilst private investment falls. However, many results from SVAR analysis imply that consumption increases following a spending shock, elements consistent with standard Keynesian theory. A selection of relevant SVAR literature on government spending multipliers is summarized in Table 4.2.

Summarizing SVAR studies of spending multipliers, the majority of estimates are in the range of 0.4 to 1.5 (Ramey, 2019). Predominantly, these studies are conducted on US data. Among the seminal papers estimating spending multipliers, Blanchard and Perotti (2002) find a consistently positive effect on GDP. Increased spending stimulates output on impact by 0.78 cents per dollar change, and peaks at a multiplier of 1.29. Perotti (2005) and Caldara and Kamps (2008) expand the approach to control for monetary policy shocks and find comparable ranges of spending multipliers. Similarly, these studies find positive effects of government spending on private consumption and the opposite on private investment. Ramey (2011) compares the effects found through these studies with findings from the narrative approach, in an attempt to incorporate anticipation effects. The study finds a positive effect on GDP, with similar multipliers as the studies above. In addition, the negative effects on private investment approximate previous studies, whereas the study finds a crowding out effect on consumption, consistent with neoclassical theory. Auerbach and Gorodnichenko (2012) applies a similar methodology to estimate multipliers dependent on the state of the economy, finding that spending multipliers are substantially larger in economic contractions than expansions. Mountford and Uhlig (2009), our main source of inspiration for the sign restrictions approach, finds a smaller effect on GDP on impact with 0.65 cents per dollar change, which is also the peak spending multiplier. Moreover, the study does not find significant effects on private consumption or investment.

As mentioned, there are limited studies conducted on economies apart from the U.S., which offer mixed support to previous literature. The aforementioned Perotti (2005) estimates spending multipliers on five OECD countries, and finds diverging effects outside of the U.S. through different time periods. When estimating smaller economies such as Australia and Canada, effects of increased spending are generally more inconclusive with different qualitative effects through different sample periods. Furthermore, Perotti (2005) and Afonso and Sousa (2009) find counterintutive, negative effects of increased spending on GDP in Germany and the UK. Among the limited SVAR studies of small, open economies approximating Norway, Grdović Gnip (2014) finds an impact multiplier of 0.33 in Croatia, while Kemp (2020) estimates impact multipliers of 0.11 and 0.36 (with recursive ordering and sign restrictions, respectively) in South Africa. Finally, Parkyn and Vehbi (2014) finds an ambiguous range of spending multipliers from -0.1 to 0.4 in New Zealand. With the exception of Kemp (2020), all of the studies in Table 4.1 outside of the U.S. employ a version of the conventional recursive ordering approach for identification.

Table 4.1: Summary of Spending Multipliers

Study	Main Sample	Identification Approach	Spending Multipliers	Country
Blanchard and Perotti (2002)	Quarterly, 1960–1997	Blanchard-Perotti approach	0.9–1.29	U.S.
Perotti (2005)	Quarterly, Spanning from 1960 - 2001	Blanchard-Perotti approach	0.41 0.48 0.59 -0.10	Germany U.K. Australia Canada
Caldara and Kamps (2008)	Quarterly, 1955 - 2006	Recursive ordering Blanchard-Perotti approach Sign Restrictions	0.9 0.9 0.1	U.S.
Mountford and Uhlig (2009)	Quarterly, 1955–2000	Sign restrictions	0.65	U.S.
Afonso and Sousa (2009)	Quarterly, 1964-2007, 1980:3-2006:4, and 1986:2-2004:4	Recursive ordering	negative negative positive	U.K. Germany Italy
Ramey (2011)	Quarterly, 1939–2008 and subsamples	Narrative Approach	0.6 –1.2	US
Auerbach and Gorodnichenko (2012)	Quarterly, 1950–2008	Blanchard-Perotti approach controlling for professional forecasts and news	Expansion: 0.3 to 0.8 Recession: 1–3.6	U.S.
Gnip (2014)	Quarterly, 1996-2011	Blanchard-Perotti approach	0.33 (peak)	Croatia
Parkyn and Vehbi (2014)	Quarterly, 1983-2010	Blanchard-Perotti approach	0.2-0.4	New Zealand
Asche and Kristjiansson (2019)	Quarterly, 1978–2017	Blanchard-Perotti approach	0.4	Norway
Kemp (2020)	Quarterly, 1970-2018	Recursive ordering Blanchard-Perotti approach Sign restrictions	0.11 0.11 0.32	South Africa

Tax Shocks

Although empirical literature often converge qualitatively on the effects of tax shocks on GDP, findings are more ambiguous with regards to the effect on components of GDP. A comparative analysis of Caldara and Kamps (2008) finds that differences are mainly due to the size of automatic stabilizers and differences in the external estimates utilized in identification. Predominantly, empirical literature finds negative tax multipliers to output, consumption and investment (Ramey, 2016). This is consistent with the negative wealth effects in the current period both in standard Keynesian and DSGE models. Moreover, these tax multipliers are generally less impactful than spending multipliers in the short-term, but grow to relatively large multipliers over time. A selection of relevant SVAR literature of tax multipliers is summarized in Table 4.2.

Most empirical literature, primarily on U.S. data, finds persistently negative effects on GDP and components thereof. However, the size of the multipliers vary greatly. Many studies of tax shocks build upon Blanchard and Perotti (2002), which utilizes institutional information to externally estimate the elasticity of net taxes to GDP and identify shocks by implication. Blanchard and Perotti (2002) finds a negative effect on impact of -0.69 cents per dollar tax increase, with a maximum multiplier of -0.78 after a year. Similarly, the study finds mildly negative effects on private consumption and investment. However, the approach has faced criticism as the identification of tax shocks is highly dependent on the externally estimated elasticity of tax to output. This is illustrated by Caldara and Kamps (2008), which find that tax multipliers change significantly when estimating this elasticity endogenously in the model. Rather, Mountford and Uhlig (2009) applies the sign restriction approach to identify present-value tax multipliers within the model, more similar to the approach of Caldara and Kamps (2008). Mountford and Uhlig (2009) finds a persistently negative effect of tax shocks, with a peak multiplier of -3.6 within three years. Romer and Romer (2010) finds similar results to Mountford and Uhlig (2009) when employing the narrative approach to identify shocks, calculating tax multipliers at a range of -2.5 to -3 within three years of a tax shock.

Similar to spending shocks, the effects of tax shocks found in studies of other OECD countries are more ambiguous. For instance, Afonso and Sousa (2009) finds a counterintuitive, positive effect on GDP in Germany and the U.K., whereas Perotti (2005) finds a positive effect of tax increases in Australia and Germany. The few studies of small, open economies commonly find smaller tax multiplier than those estimated in the US and larger countries, with tax multipliers such as -0.03 in Croatia (Grdović Gnip, 2014), -0,27 in South Africa (Kemp, 2020) and an average of -0.4 in a study of various small states across the world (Alichi et al., 2019).

Table 4.2: Summary of Tax Multipliers

Study	Main Sample	Identification	Implied tax multipliers	Country
Blanchard and Perotti (2002)	Quarterly, 1960–1997	Blanchard-Perotti approach	0.78 - 1.33	US
Perotti (2005)	Quarterly, Spanning from 1960 - 2001	Blanchard-Perotti approach	0.07 -0.14 -0.05 0.16	Germany U.K. Australia Canada
Caldara and Kamps (2008)	Quarterly, 1955 - 2006	Recursive ordering Blanchard-Perotti approach Sign restrictions	0.2 0.2 -0.8	U.S.
Mountford and Uhlig (2009)	Quarterly, 1955–2000	Sign restrictions	- 3.6	US
Afonso and Sousa (2009)	Quarterly, 1964:2-2007:4, 1980:3-2006:4, and 1986:2-2004:4	Recursive ordering	positive positive negative	UK Germany Italy
Romer and Romer (2010)	Quarterly, 1947–2007	Narrative approach	-3 (peak)	US
Favero and Giavazzi (2012)	Quarterly, 1950–2006	Narrative approach	-0.5	US
Mertens and Ravn (2012)	Quarterly, 1950–2006	Proxy SVAR using Romer-Romer unanticipated shocks	-3	US
Gnip (2014)	Quarterly, 1996-2011	Blanchard-Perotti Approach	0.04	Croatia
Parkyn and Vehbi (2014)	Quarterly, 1983-2010	Blanchard-Perotti approach	-0.2-0.2	New Zealand
Kemp (2020)	Quarterly, 1970-2018	Recursive ordering Blanchard-Perotti approach Sign restrictions	0.00 -0.20 -0.27	South Africa

Fiscal Multipliers in Norway

Concerning Norway, Boug et al. (2017) provides estimates of spending multipliers in the economy through simulations in the macroeconometric model MODAG of Statistics Norway. Contrary to more aggregated DSGE models, the model contains a detailed characterization of all government revenues and expenditures. The study finds a spending multiplier which starts at 1.0 in the short-term (within four quarters) and gradually grows to 1.6 within eight years, mainly driven through an increase in public employment. Notably, this rather large multiplier could be enhanced by the theoretical assumptions anchored in the model, where agents are backward looking and adaptive rather than forward looking, in contrast to DSGE models.

To the best of our knowledge, the only SVAR-based estimations of fiscal multipliers in Norway are found by Asche and Kristjánsson (2019),[1] which follows the Blanchard-Perotti approach to identify fiscal shocks in Norway. They find that spending shocks positively affects output, albeit with a smaller multiplier than commonly found in larger economies. On impact, Asche and Kristjánsson (2019) finds that GDP increases by 0.43 kroner following a one-krone spending shock, stabilizing at a multiplier of 0.5-0.6 throughout the period. Regarding tax multipliers in Norway, Asche and Kristjánsson (2019) applies two different methods to estimate the tax elasticity to output and consequently calculate tax

[1] With the exception of certain master theses, see e.g. Thuy Dinh and Vegard (2018); Lund (2005).

multipliers. First, following Blanchard and Perotti (2002), the study externally calculates a tax elasticity of output ranging from 0.9 to 1.8, implying that a 1% increase in GDP raises net taxes from 0.9% to 1.8% within the current period. With this tax elasticity, the tax multiplier is positive ranging from 0.1 to 0.4. In contrast, estimating the tax elasticity to output endogenously in the model following Caldara and Kamps (2008), the study finds a tax elasticity of 2.9 which yields a negative tax multiplier of -0.3. Thus, the tax multipliers found by Asche and Kristjánsson (2019) are not conclusive.

Aiming to add novel insight to the literature of the effects of fiscal policy, we follow Mountford and Uhlig (2009) in using the sign restrictions approach to employ an agnostic identification strategy for fiscal shocks in a small, open economy such as Norway.

5 Empirical Strategy

5.1 Choice of Identification Approach

Identification of structural parameters, and fiscal shocks by implication, has primarily relied on recursive ordering since Sims (1980). The recursive ordering method utilizes a Cholesky decomposition of the variance-covariance matrix of the reduced form residuals in the model. In essence, restrictions are imposed to limit contemporaneous structural relationships either to zero and/or estimated parameters in the short and long-run from theory-based assumptions. This is the approach of Blanchard and Perotti (2002), for instance when imposing the externally estimated elasticity of tax to output. With these restrictions, the shocks of endogenous variables are identified in a specific order based on prior beliefs. Hence, the recursive ordering approach implies strong assumptions on parameters and the chain of causation within the model (Breitenlechner et al., 2019).

In contrast, the sign restrictions approach limits such assumptions on the chain of causation and parameters describing the contemporaneous relationships. Instead of imposing assumptions on the impact matrix itself, the approach imposes restrictions on the direction of the impulse responses, i.e. the dynamic effects of the endogenous variables following a shock. Moreover, the approach does not determine the sequence of causation in the model, allowing all variables to respond to identified shocks simultaneously (Breitenlechner et al., 2019).

5.2 SVAR and Sign Restrictions

In line with previous literature, we employ a Structural Vector Autoregressive (SVAR) model in our empirical analysis. First, consider the matrix form of our baseline three-variable VAR model:

$$\begin{pmatrix} GDP_t \\ Spending_t \\ Net\ Taxes_t \end{pmatrix} = \begin{pmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{pmatrix} \times \begin{pmatrix} GDP_{t-1} \\ Spending_{t-1} \\ Net\ Taxes_{t-1} \end{pmatrix} + \begin{pmatrix} \epsilon_{1,t} \\ \epsilon_{2,t} \\ \epsilon_{3,t} \end{pmatrix} \tag{5.1}$$

This can further be illustrated as follows:

$$y_t \;=\; B_1\, y_{(t-1)} + ... \; + B_p\, y_{(t-p)} \;\; + \; \epsilon_t, \tag{5.2}$$

or more compactly using the lag operator L:

$$B(L)y_t = \epsilon_t, \tag{5.3}$$

where $B(L) \; = \; B_0 \; - B_1L \; - \; .... \; - \; B_pL^P$.

In Equations 5.1 - 5.3, y is a $n \times 1$ vector containing the endogenous variables of interest. Following Blanchard and Perotti (2002), we include logged, per capita values of real GDP, government spending and net taxes as endogenous variables in our system. B_i represents the $n \; \times \; n$ matrix of coefficients, and ϵ_t represents the reduced form white noise with zero mean and a variance-covariance matrix $\sum_\epsilon = E[\epsilon_t, \; \epsilon_t']$, where $E[\epsilon_t, \; \epsilon_s'] = 0$ for $s \neq \; t$.

Ideally, we would want to estimate the model as it is. However, due to concerns that the reduced form residuals are often correlated, the matrix $\sum_\epsilon$ is not likely to be a diagonal matrix. Hence, a shock in one variable is likely to be accompanied by a shock in another variable and is therefore not orthogonal. In order to estimate the exogenous effects of spending and tax shocks with economic meaning, we need to construct a structural representation of the VAR model (Kilian, 2013). The structural representation is as follows:

$$Ay_t = \sum_{i=1}^{\infty} B_i y_{t-i} + u_t \tag{5.4}$$

Here, A describes the contemporaneous relationships among the endogenous variables in y_t, which is also referred to as the impact matrix. B_i is an $n \; \times \; n$ coefficient matrix of the variables, and u_t are independent structural shocks with $\sum_u = E[u_t, \; u_t'] = I$.

In order to identify and characterize the structural shocks, further information on the contemporaneous relationships between the variables in A is required. Conventionally, identification is achieved through identifying all fundamental shocks, denoted m, and characterizing the entire A matrix. To this aim, $\frac{m(m-1)}{2}$ restrictions must be inferred on the A matrix. To solve this identification challenge, we apply the sign restriction approach as proposed by Uhlig (2005).

Formal Representation of Sign Restrictions

The underlying mechanisms of sign restrictions can be illustrated through a moving average representation of our reduced-form VAR model in equation 5.3:

$$y_t = \sum_{i=1}^{\infty} \Phi_i \epsilon_{t-1} \tag{5.5}$$

In this equation Φ_i encompasses the reduced form impulse responses, where $\Phi_0 = I$ and $\Phi_i = \sum_{n=1}^{\infty} \Phi_{i-j} B_j$. With the use of Cholesky decomposition we assume that $\sum_\epsilon \ = \ PP\prime$. It then follows that since $y_t = \sum_{n=1}^{\infty} \Phi_i P P^{-1} \epsilon_{t-1}$, the structural variance-covariance matrix can be identified as $\sum_u \ = \ P^{-1} E[\epsilon_t, \ \epsilon_t'] \ P^{-1}\prime \ = \ P^{-1} PP\prime \ P^{-1}\prime = I$. Since P is a lower triangular matrix, it has $K(K+1)/2$ free parameters, so all parameters of P are exactly identified. As a result, the order condition for identification is satisfied. We would as such obtain the structural impulse responses denoted Θ_i, as $\Theta_i = \Phi_i P$.

While the Cholesky decomposition imposes a recursive order with zero restrictions on the contemporaneous relationships, the sign restriction approach imposes restrictions directly on the impulse responses Θ_i given a horizon i. Thus, it follows that one would not exactly identify the structural shocks through matrix A, as multiple orthogonalizations might be consistent with the imposed sign restrictions. In the implementation of sign restrictions one decomposes the matrix containing the contemporaneous relationships, A, into two components, $A = PQ$, where P is the lower triangular Cholesky factor of $\sum_\epsilon$ and Q is an orthonormal matrix with $QQ\prime = I$. Note that the matrix P, which serves to identify the structural shocks in the recursive approach, here serves merely as a useful computational tool without affecting the results. Conversely, the matrix Q plays an important role in the sign restrictions approach because it collects the identifying weights with each column of Q corresponding to a particular structural shock. To obtain another orthogonal representation of the impulse responses in Equation 5.5, we can now further multiply $\Theta_i = \Phi_i P$ with a random orthonormal matrix Q. It will then still hold that $\sum_u \ = \ E[\ Q\prime P^{-1} \epsilon_t \ \epsilon_t' \ P^{-1}\prime \ Q \ ] = I$.

The identification approach further takes several draws from the posterior of the VAR coefficients and the variance-covariance matrix of the reduced-form residuals. For each draw, the obtained orthogonal impulse response is checked for a match against the imposed positive or negative sign restrictions. If they match the sign restrictions, the impulse responses bear a structural meaning and are saved. If not, they are discarded. For further elaboration on sign restrictions, see Arias et al. (2014).

Identifying Assumptions

In order to characterize meaningful relationships, economic theory and experience should be emphasized when imposing assumptions on the direction of the sign restrictions (Uhlig, 2017). However, these assumptions are not necessarily agreed upon in literature. Following seminal empirical literature using sign restrictions, notably Mountford and Uhlig (2009), we impose restrictions based on the identifying assumptions in Table 5.1. Although one aims to be agnostic in the analysis, some identifying assumptions are needed to interpret relationships (Mountford and Uhlig, 2009). According to Paustian (2007), the model is incapable of precise identification without sufficient restrictions to pin down the effects on the endogenous variables. In addition to the signs imposed on fiscal shocks, business cycle shocks are identified to control for movements correlated to business cycle fluctuations.

Table 5.1: Imposed Sign Restrictions

	GDP	Spending	Net Taxes
Business Cycle Shock	+		+
Spending Shock		+	
Tax Shock			+

Note: '+' indicates that the impulse responses are restricted to be positive after a shock. Similarly, '-' restrict the responses to be negative. Lastly, blank fields indicate no restrictions

Fiscal policy shocks are identified through imposed sign restrictions on the impulse responses of the fiscal variables, and the requirement that they are orthogonal to business cycle shocks (Mountford and Uhlig, 2009). Spending and tax shocks are defined as persistent increases in government spending and net taxes, respectively, for at least four consecutive quarters. We employ tight identifying restrictions of at least four quarters in order to disregard transitory shocks to fiscal variables, for instance cases where spending rises on impact and falls again after one or two periods.

Moreover, business cycle shocks are defined as shocks which persistently moves output and net taxes for four quarters after the shock. The inclusion of business cycle shocks is crucial for identification of fiscal policy shocks, as it allows us to control for co-movements in output and taxes. When output and net taxes move in the same direction, a business cycle upswing is assumed to yield increased tax revenue rather than the opposite. This assumption is reasonable in view with theoretical and empirical literature (Mountford and Uhlig, 2009), and is important to avoid incorrectly attributing positive GDP responses to tax shocks (Caldara and Kamps, 2017). Moreover, the values that are blank in Table 5.1 are not restricted to any value and thus the approach does not affect these relationships.

Several studies have proposed different algorithms to implement these sign restrictions. In recent years, the computational modelling of Mountford and Uhlig (2009) has been questioned with respect to the proclaimed agnosticism when identifying shocks. In particular, Arias et al. (2014) argues that the algorithm unknowingly imposes additional restrictions, generating biased impulse response functions and artificially narrow confidence bands. In response, Arias et al. (2014, 2018) builds upon the work of Mountford and Uhlig (2009) to develop an algorithm which takes into account such shortcomings. In our analysis we therefore use a replication algorithm of Arias et al. (2014) to conduct our sign restricted approach.[2]

5.3 Other Specifications and Choice of Estimator

In a Structural VAR analysis, the choice of appropriate lag lengths is a central point of discussion. An insufficient amount of lags could lead to a loss of important information or cause biased estimates due to autocorrelation in the residuals. On the other hand, more lags might make the model excessively complex and cause imprecise estimates (Bjørnland and Thorsrud, 2015). With relatively few observations of quarterly data from 1978 to 2017, this could be an issue for our VAR model. Utilizing formal information criterion functions, both the Akaike information criterion (AIC) and the Bayesian Information Criterion (BIC) suggest two lags with our baseline model. However, according to DeSerres et al. (1995), applying the information criteria can yield too short suggested lag lengths. Although Mountford and Uhlig (2009) includes six lags, four lags are common for three-variable VAR models including those of Blanchard and Perotti (2002) and Asche and Kristjánsson (2019). Accordingly, we include four lags to the endogenous variables in our model. We test the sensitivity of our baseline model with two and six lags, following recommendations of our AIC/BIC criteria (two lags) and studies such as Mountford and Uhlig (2009) which

[2]The approach is based on the ZeroSignVar package developed by Breitenlechner et al. (2019), and conducted in MATLAB. For a more detailed description of the software process, see Appendix A1.

applies six lags. This does not significantly affect the results of our baseline model (see Appendix A5.1).

Following Uhlig (2005), we estimate our model using Bayesian techniques. This includes utilizing an uninformative Normal – Inverse – Wishart Prior as our prior and a corresponding Normal-Wishart density as the posterior distribution. This is a flat prior commonly used in literature which returns point estimates that closely resemble those of traditional ordinary least squares method. The rationale behind applying Bayesian techniques is mainly built on two arguments. First, the Bayesian approach does not require special treatment if unit roots are present in the time series (Sims and Zha, 1998). As unit roots often appear in macroeconomic variables, our series would require special treatment to achieve stationarity. However, this may be undesirable as important data points could be lost in the process, as Sims (1980) argues. As such, a Bayesian approach proves beneficial to the estimation of macroeconomic outcomes. Second, as most studies implementing a sign restrictions approach use Bayesian techniques, it is in our interest to follow this literature to obtain a comparative basis for discussion.

Although the Bayesian VAR technique in principle allows for a trend present in the variables (Nalban et al., 2015), most previous literature including Blanchard and Perotti (2002) and Asche and Kristjánsson (2019) have included time trends. Consequently, we include a linear time trend in our VAR model.[3] However, we test the sensitivity of our results when excluding the linear time trend similar to Mountford and Uhlig (2009), which argues that the exclusion yields more robust results although leading to a slight misspecification. Excluding a linear time trend does not significantly affect our results, illustrated in Appendix A5.1.

[3]When applying the above specifications, the Lagrange multiplier test in Appendix A6.5 indicates that there is no autocorrelation in the residuals in the VAR. Importantly, the eigenvalue stability condition is satisfied, implying that the model is stable.

6 Data

6.1 Collection of Data

This thesis utilizes panel data of Norwegian macroeconomic variables. The data in our baseline model is collected from Statistics Norway with quarterly frequency over the time period 1978Q1:2017Q4.

First, our three-variable VAR model combines quarterly series of Norwegian GDP, government spending and net taxes. GDP and government spending are acquired from the publicly available national accounts presented by Statistics Norway, whereas the net taxes variable is collected from the KVARTS database, provided by the Norwegian Ministry of Finance. GDP refers to the market value of GDP for Mainland Norway, which has become the main emphasis when assessing effects on the Norwegian economy. Mainland GDP excludes petroleum production and international shipping. As a large part of gross product in Norwegian petroleum extraction is derived from resource rent taxation, this exaggerates the importance of the sector in terms of GDP relative to the input of production factors. Shipping, meanwhile, is excluded as it has shown to have limited explanatory power with respect to fluctuations in economic activity (Eika and Olsen, 2008).

In line with previous literature (Blanchard and Perotti, 2002; Mountford and Uhlig, 2009), we combine public consumption and gross public investment in government spending. In addition, we follow the approach of Asche and Kristjánsson (2019) on Norwegian data and deduct quarterly depreciation of government physical capital. The data series for depreciation is provided by the Ministry of Finance. Similarly, for a comparative basis with previous literature, we estimate taxes through a calculation of quarterly net tax revenues. Following Blanchard and Perotti (2002) and Mountford and Uhlig (2009), net taxes are defined as total public revenues less transfers and net capital interest. Transfers include social and other transfers (e.g. foreign aid), which are typically regarded in literature as negative taxes and thus excluded from the variable. Furthermore, similar to Asche and Kristjánsson (2019), we deduct all petroleum revenues from the net taxes variable. In line with the fiscal framework described in section 2, the deduction is made as government revenue from petroleum exploration is transferred in its entirety to the Sovereign Wealth

Fund, and gradually phased into the economy corresponding to the expected real return of the fund (Gjedrem, 2019). In addition, similar variable calculations as in relevant literature aid us in not obscuring the results through differentiating in more than one aspect, the identification method, and achieve comparable results to those of Asche and Kristjánsson (2019).

Moreover, we expand our baseline model in a sensitivity analysis. First, we estimate a five-variable VAR including private consumption and private investment from 1978:Q1 to 2017:Q4. As components of GDP, both private consumption and private investment were also collected from the national accounts of Statistics Norway. Private consumption encompasses quarterly consumption of households and ideal organisations. Private investment, meanwhile, includes all gross real investment of Mainland Norway less government investment and residential investment, in accordance with previous literature (Mountford and Uhlig, 2009).

Second, we analyze sensitivity of our baseline results in a five-variable VAR controlling for monetary policy shocks. To this end, we include the Norwegian Inter Bank Offered Rate (NIBOR) and the aforementioned GDP deflator. The NIBOR rate represents the 3-month interbank rate in Norway. The time series were collected from the Federal Reserve database (FRED), and encompasses the longest period for which NIBOR is available from 1979 to 2017. This implies that there are four less observations of the NIBOR rate, and thus the second sensitivity analysis is conducted from 1979:Q1 to 2017:Q4. In addition, we include a GDP deflator to the five-variable model which we construct based on fixed and current prices of Mainland GDP. This construction is described below.

6.2 Treatment of Data

With the exception of net taxes and government depreciation, the data collected from Statistics Norway were obtained in fixed 2018 prices. Thus, to obtain comparable real values for net taxes and government depreciation, we followed previous empirical literature and deflated the aforementioned nominal series. Net taxes were deflated using the GDP deflator for mainland GDP as is commonly done in literature, while depreciation was deflated using its own deflator.

The GDP deflator with index (2018 = 100) was constructed using the ratios of fixed 2018 prices and nominal prices of quarterly Mainland GDP, as presented in Statistics Norway's national accounts. Moreover, we constructed a Mainland GDP deflator as to not bias our results using a deflator incorporating inflation from petroleum activity. Alternative to the constructed GDP deflator, one could consider implementing the CPI-ATE (Consumer Price Index adjusted for tax changes and energy products), commonly used by the Central Bank to target the core inflation measure. However, this measure was not publicly available for the entire sample period. Furthermore, utilizing a GDP deflator over a CPI measure is arguably more suited to capture broad macroeconomic price developments. Whereas the CPI-JAE predominantly targets price developments within consumed goods and services, the GDP deflator includes price developments in net exports, gross investment and government spending. However, a notable caveat is that the GDP deflator for Mainland Norway only incorporates inflation for domestically produced goods and services, and will therefore not account for imported inflation.

The data series for government depreciation is deflated by a deflator constructed through current and fixed 2018-prices of gross public investment. Thus, the final data series for government spending constitutes fixed prices of government consumption and investment, minus the deflated series of depreciation. Alternatively, we could also have used the GDP deflator on current prices for government spending, which is previously done in literature. However, our results do not change significantly when testing for it (see Appendix A5.1). Thus, to obtain a comparable basis for our baseline results, we stay consistent with previous literature on Norwegian fiscal policy (Asche and Kristjánsson, 2019) and apply the fixed prices provided by Statistics Norway. After deflating net taxes and constructing the combined spending series, all our data series illustrate real values in fixed 2018-prices.

Moreover, with the exception of net taxes and depreciation, the aforementioned data series were all seasonally adjusted by Statistics Norway. To stay consistent with their adjustments, we seasonally adjusted taxes and depreciation in a similar manner using the X-12 Arima method. The X-12 Arima method is commonly used among statistic bureaus and is frequently used by Statistics Norway. This transformation can be found in Appendix A2.2. Furthermore, we divided the data series by Norwegian quarterly population to obtain per capita values. As quarterly population data is unavailable from 1978:Q1 to

1997:Q4, these were computed through linear interpolation of yearly data. Finally, all variables were transformed from level to log values with the exception of the interest rate, which is expressed in level form. This is common following previous literature (Bjørnland, 2009), as the latter variable is already measured as a ratio.

6.3 Descriptive Statistics

Our final data in the baseline model comprises quarterly observations from 1978 to 2017,[4] representing the time period for which our variables of interest were available, in particular with respect to net taxes provided by the Ministry of Finance. In real values, our data comprises the following distribution of observations:

Table 6.1: Summary Statistics

	Obs	Min	Max	Mean	Median	Std
GDP	160	274 913	726 087	466 743	447 560	139 533
Government Spending	160	79 659	223 616	144 457	143 951	42 655
Net Taxes	160	51 814	150 781	94 414	91 419	34 400

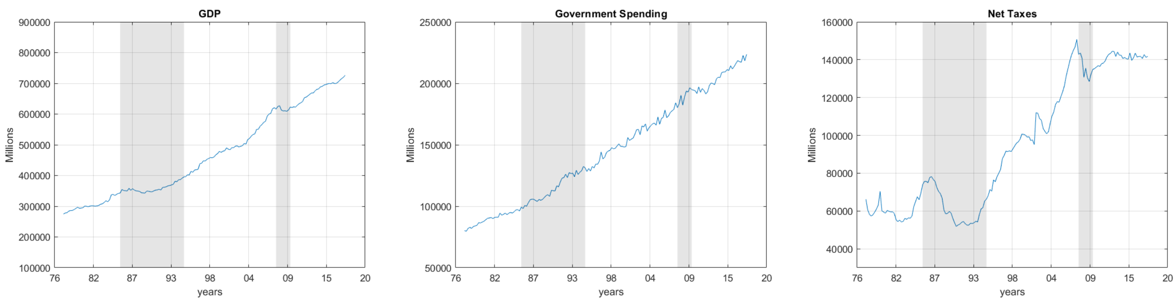

Figure 6.1: Real Values of Mainland GDP, Government Spending and Net Taxes in millions of NOK from 1978 to 2017. Shaded areas indicate recessions in Norway.

Figure 6.1 illustrates our variables in the baseline three-variable VAR model. The plotted values are all in fixed 2018-prices and are seasonally adjusted. From the plots in 6.1 it appears that the data series are non-stationary, but it is not clear whether the variables demonstrate a stochastic or deterministic trend. Government spending has a seemingly clear trend from 1978 to 2017. This is expected, as increasing petroleum revenues have been gradually phased in to cover national budget deficits throughout the period. The series

[4]Summary statistics and plots of the additional data for the sensitivity analyses can be found in Appendix A2

of GDP illustrates a clear trend, although characterized by large fluctuations connected to the Norwegian banking crisis and the Great Recession (shaded in the figure). Finally, net tax revenues illustrate a more irregular trend throughout the period, and as expected mirror the stochastic fluctuations of GDP development with respect to said recessions.

However, the graphical analysis is not sufficient to determine whether the data series are stationary or not. Rather, we conduct an Augmented Dickey Fuller test on each of the log-transformed data series, which can be found in Appendix A6. From the test, we cannot reject the null hypothesis of a unit root at a 5% level for any of the data series. Thus, our data series in log-form are non-stationary. We are able to obtain stationary data by taking the first difference of the data series. However, similar to previous literature (Blanchard and Perotti, 2002), we keep our data in log-form as we focus our analysis on the structural relationships of fiscal policy shocks. In this regard, differenced data could lead to the loss of important data points, as previously discussed.

7 Results

7.1 Baseline Model

First, we present the results from our three-variable baseline model. To obtain a solid foundation for inference, we transform all responses of the endogenous variables to give the krone response of each variable at a given period to the initial, one-krone shock to spending or net taxes. Therefore, in line with previous literature (Blanchard and Perotti, 2002; Caldara and Kamps, 2017), we divide the original impulse responses by the standard deviation of the fiscal shock in question to compute one-krone impact shocks. Furthermore, these impulse responses are divided by the sample average of the ratio of the macroeconomic outcome of interest and the fiscal variable subject to a shock. The re-scaled impulse responses thus illustrate constant, non-accumulated krone multipliers on output, taxes and spending to a one-krone shock in either taxes or spending.

In addition, we calculate cumulative, present-value multipliers on output at each quarter throughout 20 quarters, determined by the integral between the response of GDP and the response of the fiscal variable subject to a shock. Several studies since Blanchard and Perotti (2002) have argued that, although multipliers per quarter are useful for comparing impulse response functions, cumulative multipliers that account for the relative change in spending or tax levels are more suitable to address the relevant policy questions (Ramey, 2016). Therefore, following studies such as Perotti (2005) and Mountford and Uhlig (2009), we calculate cumulative, present-value multipliers at horizon k as follows:

$$\frac{\sum_{j=0}^{k}(1+r)^{-j}y_{t+j}}{\sum_{j=0}^{k}(1+r)^{-j}f_{t+j}} \times \frac{1}{f/y}, \tag{7.1}$$

where y_{t+j} and f_{t+j} represent the responses of output and the fiscal variable at horizon j, while r is the average nominal interest rate throughout the sample period. f/y represents the average ratio of the fiscal variable to GDP over the sample.

Alongside the median impulse response to a fiscal shock, we present confidence bands of the estimated effects at the 16% and 84% level, as is the standard in fiscal policy literature. Following Sims and Zha (1998), confidence bands at these levels are commonly applied to better communicate the qualitative shape of the results than with 95% confidence bands. If both the upper and lower confidence bands are on the same side of zero, the effects are considered statistically significant in similar analyses. A caveat of these confidence bands is that statistical significance is more easily interpreted, and thus there is a larger possibility for type 2 errors than with 95% confidence bands.

Figure 7.1: Impulse Response Functions following a spending shock. The solid lines describe the median impulse responses, while the broken lines represent confidence bands at the 16% and 84%. G: Government Spending, T: Net Taxes, Y: GDP

Table 7.1: Multipliers for a Spending Shock

	1st Quarter	4th Quarter	8th Quarter	12th Quarter	20th Quarter	Peak
GDP	0.07	-0.21	0.08	0.26	0.48*	0.48* (20)
Spending	1.00*	0.50*	0.44*	0.40*	0.34*	1.00* (1)
Tax	0.13	-0.16	-0.09	-0.04	0.22	0.22 (20)
Cumulative	0.06	-0.15	-0.07	0.08	0.41	0.41 (20)

Following a government spending shock, all variables of interest respond on impact. A spending shock increases government spending by unity (one-krone) in the first quarter and steadily decreases throughout the period back towards the trend. Nevertheless, the level of government spending is still larger after five years than what it would have been without such a spending shock. The response of taxes following a spending shock is close to zero in the short-term. This suggests that increases in government spending are financed through other means than taxes, which is plausible given the Sovereign Wealth Fund mechanism for covering budget deficits.

We find that a government spending shock has a mildly positive initial effect on output. On impact, a one-krone spending shock raises output by 0.07 kroner. The positive impact multiplier is expected, as theoretical and empirical literature predict positive effects, although the effect is smaller than commonly found in empirical literature. Although studies of smaller economies find spending multipliers of comparable magnitude (IMF, 2018; Kemp, 2020), the positive impact multiplier in our case is not statistically significant. Thus, it is hard to conclude with confidence on the initial effect on GDP. This is further supported by the calculation of present-value cumulative multipliers, which follow a similar pattern and are generally close to zero.

After the positive impact multiplier, the spending multiplier turns negative for four quarters before gradually growing positive again. The estimated effect on GDP is positive from the sixth quarter onwards, stabilizing at a spending multiplier of 0.5 before mean reverting in the long run. The short period of negative multipliers is rather unexpected, as theory and most empirical literature predict increased spending to have a positive effect on GDP, at least in the short run. However, the short-run effects of spending shocks are more ambiguous in studies outside of the U.S., and negative effects on GDP are found in other OECD countries such as Germany, Canada and the U.K. (Perotti, 2005; Afonso and Sousa, 2009).

Interestingly, the form of the impulse response function is comparable to the results of Asche and Kristjánsson (2019), also analysing fiscal shocks in Norway. Although the former study finds a larger and significant impact multiplier, the positive effects on GDP in the long run approximate those found by Asche and Kristjánsson (2019). This may suggest that the sign restrictions approach estimates a similar impulse response pattern following spending shocks, although finding less significant multipliers in the short run. This is consistent with previous studies employing sign restrictions for identification of fiscal shocks (Caldara and Kamps, 2008), where the initial impact is close to zero and insignificant before growing gradually positive and significant through the period. However, it should be noted that estimates of the effects at longer time horizons generally offer less credibility when extrapolating policy implications.

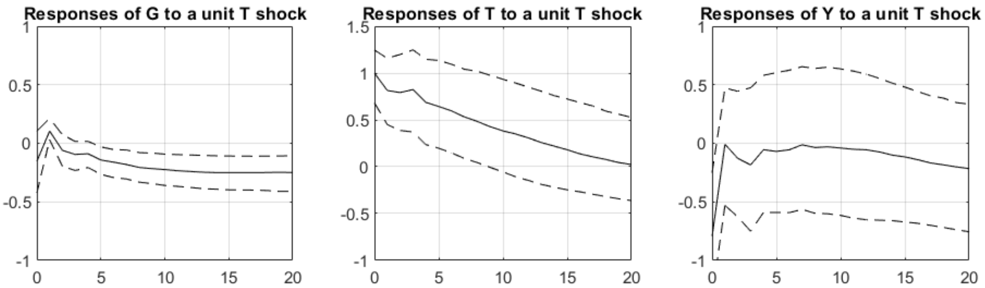

Figure 7.2: Impulse Response Functions following a tax shock. The solid line describe the median impulse responses, while the broken lines represent confidence bands at the 16% and 84%. G: Government Spending, T: Net Taxes, Y: GDP

Table 7.2: Multipliers for a Tax Shock

	1st Quarter	4th Quarter	8th Quarter	12th Quarter	20th Quarter	Peak
GDP	-0.79*	-0.19	-0.01	-0.05	-0.22	- 0.79* (1)
Spending	-0.15	-0.10	-0.18*	-0.23*	-0.25*	-0.25*(16)
Tax	1.00*	0.82*	0.53	0.35	0.04	1.00* (1)
Cumulative	-0.79	-0.32	-0.22	-0.19	-0.28	-0.79 (1)

Following a tax shock, all variables of interest respond on impact. Similar to the effect of a spending shock on the level of spending, the response of tax revenue peaks on impact before gradually reverting. The positive effect on net tax revenue is substantially higher for several years following the tax increase, while the level of government spending is not particularly affected. We find that a positive tax shock yields a significant, negative impact multiplier on GDP, where a one-krone tax increase reduces output by -0.79 kroner. This is expected, as the central theoretical frameworks predict a negative tax multiplier. However, the impact and peak multiplier of tax shocks is substantially larger than the corresponding spending multipliers. This finding favors predictions of DSGE models, as taxes only enter standard Keynesian models as a negative effect on current income, predicting smaller multipliers than those following spending shocks.

Generally, the effect on output from a tax increase is negative throughout the time horizon. This is consistent with most previous empirical literature, and our estimated tax multiplier on impact is similar to the estimates found by e.g. Blanchard and Perotti (2002) and Mountford and Uhlig (2009). However, these and other studies of tax shocks find that the negative effects of tax shocks grows gradually and tend to peak (bottom) within 1 to 3 years (Ramey, 2016). Conversely, we find that the negative effect is strongest on impact, after which the negative effect is weak and at times approximating zero up until the third year following a shock. Subsequently, the negative effect on the economy grows marginally from the 10th quarter onwards and stabilizes at a multiplier of approximately -0.25. Accounting for the simultaneous changes to net tax levels through the calculation of cumulative multipliers, we find very similar effects to the non-accumulated tax multipliers. Nevertheless, with the exception of the initial impact multiplier, the negative effects on GDP are not statistically significant through the time horizon.

Discussion of Baseline Results

Given the large presence of government spending and an extensive tax base in Norway, we would expect to find a more significant influence from fiscal shocks. Nonetheless, studies of economies more comparable to the Norwegian in size and openness find inconclusive effects of fiscal policy (Perotti, 2005; Afonso and Sousa, 2009; Parkyn and Vehbi, 2014), which could imply that fiscal shocks affect the economy differently in smaller, open economies. Several characteristics of the Norwegian economy could drive these insignificant effects.

In particular, estimation of fiscal policy effects has shown to be sensitive to the state of the economy, the level of openness and development, and the exchange rate regime within an economy (Ramey, 2016). For instance, Auerbach and Gorodnichenko (2012) show that fiscal multipliers are heavily influenced by the state of the economy, finding significantly larger effects in recessions than expansions. The Norwegian economy has experienced a relatively prolonged state of expansion since the Norwegian banking crisis in the late 80s and early 90s, and was less affected by the Great Recession than many other countries due to the stabilization policies previously discussed. Thus, it could be that the effects of spending and tax multipliers have been smaller in Norway through the sample period. Regarding the openness and exchange rate regime, standard and New-Keynesian theory incorporating sticky prices predict that fiscal multipliers are smaller in open economies than more closed ones (Hebous, 2011). This has further been empirically supported by studies of small, open economies such as New Zealand (Parkyn and Vehbi, 2014), Croatia (Grdović Gnip, 2014) and South Africa (Kemp, 2020), which commonly find smaller multipliers for spending and tax shocks than larger economies. As Norway represents a small, open economy with a floating exchange rate, there could arguably be smaller effects to be found from domestic fiscal policy.

Moreover, as shown by previous literature (Caldara and Kamps, 2008), the identification of exogenous spending and tax shocks is sensitive to underlying mechanisms in the fiscal framework, in addition to the characteristics and persistence of identified fiscal shocks. Consequently, it may be that Norway is prone to inconclusive results on fiscal policy effects due to a limited amount of identified fiscal shocks. For instance, several studies in the U.S. find significant effects of spending shocks related to military build-ups in the outbreak of war (Romer and Romer, 2010; Caldara and Kamps, 2008). In contrast, Norway appears to have experienced few persistent shocks to government spending or net tax levels of the same magnitude. Indeed, when reviewing the primary changes to the Norwegian tax system throughout our sample period, we find that most reforms have focused on the structure of taxation rather than the level of net taxes. Namely, large tax reforms in 1992 and 2006 focused upon changes to marginal tax rates and broader tax bases, such as changing the balance between capital and income tax rates and change rules of tax deductions (Thoresen et al., 2010; NOU2003:9, 2003). Such tax system changes are not necessarily captured in SVAR studies investigating spending and tax levels, which implicitly assumes that fiscal policy affects the economy primarily through demand-side channels (Blanchard and Perotti, 2002).

Thus, a plausible cause of our inconclusive findings could be a limited amount of identified fiscal shocks in our data. This may partly be due to the characteristics of the Norwegian government and the budgetary process. First, the process of fiscal decision-making in Norway may cause limited exogenous fiscal shocks due to several factors. The annual budget is proposed by the current administration, before being negotiated and determined within the Norwegian Parliament. These budgetary proposals and ensuing negotiations have been subject to lengthy discussions and few large changes seem to prevail. While administrations have been subject to coalition governments, budget negotiations within the Parliament are characterized by opposing debate and alternative proposals. This could pose less room for manoeuvre for a particular government to implement large policy changes. Moreover, an influential factor could be that opposing political parties in Norway through the sample period have been rather similar and centrist in the discussion of large fiscal policy structures. Although significant fiscal policy changes have occasionally been promoted ahead of an election or shift in political power, most changes to budgetary decisions seem to affect marginal tax rates and facilitate automatic stabilizers, rather than conduct large exogenous spending increases and tax cuts. Thus, there may be less of a desire to conduct large fiscal changes from one government to the next than in other countries, causing limited shocks to tax or spending levels.

Second, even if a government wanted to exert large changes, the majority of spending and tax decisions in the annual national budget are predetermined components, following well-established patterns that only change incrementally. Thus, there is a limited share of spending or tax decisions for which large changes are likely to occur.

Third, the Sovereign Wealth Fund in the Norwegian Fiscal Framework could be a contributing factor to the lack of large changes to spending and tax levels. Fiscal policy in Norway aims for a limited budget deficit to be covered by an expected real return of 3% of the Sovereign Wealth Fund. Although this allows for increasing spending levels over time as the fund grows, this also implies that large spending changes are less expected, as the fiscal rule somewhat limits the fiscal room for manoeuvre for each government. Similarly, with the stable withdrawal of funds to cover budget deficits since 1992, there has arguably been less of a need for sizeable tax changes. In consequence, these underlying factors seem to induce a lack of substantial exogenous shocks to government spending and net tax levels through our sample period.

Last, fiscal policy and the effects on the Norwegian economy could be subject to influence from variables not included in this model, causing an omitted variable bias. For instance, the inclusion of key indices of interest rate and price developments could aid the approach in the isolation of truly exogenous fiscal shocks. As such, it could be an interesting exercise to impose similar sign restrictions to a model adding other potentially influential variables. To this end, we expand our baseline model to two separate five-variable VAR models to conduct sensitivity analyses of our baseline findings.

7.2 Sensitivity Analyses

Five-Variable VAR with Private Consumption and Private Investment

First, we expand the model to a five-variable VAR with two large components of GDP, including private consumption and private investment. Following Equation 5.1 we can write our expanded model as:

$$\begin{pmatrix} GDP_t \\ Spending_t \\ Net\ Taxes_t \\ Private\ Consumption_t \\ Private\ Investment_t \end{pmatrix} = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{15} \\ B_{21} & B_{22} & \cdots & B_{25} \\ \vdots & \vdots & \ddots & \vdots \\ B_{51} & B_{52} & \cdots & B_{55} \end{pmatrix} \times \begin{pmatrix} GDP_{t-1} \\ Spending_{t-1} \\ Net\ Taxes_{t-1} \\ Private\ Consumption_{t-1} \\ Private\ Investment_{t-1} \end{pmatrix} + \begin{pmatrix} \epsilon_{1,t} \\ \epsilon_{2,t} \\ \epsilon_{3,t} \\ \epsilon_{4,t} \\ \epsilon_{5,t} \end{pmatrix} \tag{7.2}$$

Similar to our baseline VAR model, we use four lags and a trend variable in our expanded model. We also include additional restrictions as proposed in table 7.3.

Table 7.3: Imposed Sign Restrictions Including Private Consumption and Investment

	GDP	Spending	Net Taxes	Private Consumption	Private Investment
Business Cycle Shock	+		+	+	+
Spending Shock		+			
Tax Shock			+		

Note: '+' indicates that the impulse responses are restricted to be positive after a shock. Similarly, '-' restrict the responses to be negative. Lastly, blank fields indicate no restrictions

The inclusion of these components of GDP is interesting in itself, as the literature predominantly limits the analysis to effects on aggregate output. Furthermore, where the central theoretical frameworks generally converge on the effects on GDP, there is no theoretical consensus on the effects on consumption and private investment following spending and tax shocks. Related empirical literature investigating these effects offers mixed support (Ramey, 2016). Consequently, in addition to assess the sensitivity of our baseline results, the inclusion of these key components of Norwegian GDP provides a valuable contribution to the discussion of fiscal policy in small, open economies.

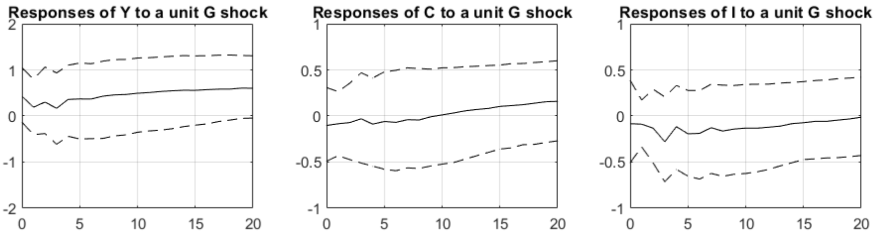

Figure 7.3: Impulse Response Functions following a spending shock. The solid line describe the median impulse responses, while the broken lines represent confidence bands at the 16% and 84% level. G: Government Spending, C: Private Consumption, I: Private Investment, Y: GDP

Table 7.4: Multipliers for a Spending Shock

	1st Quarter	4th Quarter	8th Quarter	12th Quarter	20th Quarter	Peak
GDP	0.43	0.167	0.43	0.51	0.60	0.60 (20)
Consumption	-0.10	-0.03	-0.04	0.06	0.15	0.15 (20)
Investment	-0.08	-0.28	-0.13	-0.12	0.03	-0.28 (4)

We find a mild, negative effect of a spending shock on private consumption, where a one-krone spending increase reduces consumption by 0.10 kroner on impact. Thus, our findings are consistent with neoclassical assumptions, implying that government spending crowds out private consumption due to a negative wealth effect on permanent income (Friedman, 1957). Comparable, negative effects on consumption are found in studies of economies such as Germany and Italy (Afonso and Sousa, 2009). However, the negative multiplier is quite weak and nulled out within three years, after which the effects turns positive and peaks at a multiplier of 0.15. In addition, these estimates are not statistically significant throughout the time horizon. Therefore, conclusive inference of the effect on private consumption is limited.

Furthermore, we find that an increase in government spending negatively affects private investment. On impact, a one-krone spending increase reduces private investment by -0.08 kroner. This negative effect is persistent throughout the time horizon, reaching a trough within a year at a multiplier of -0.28. This supports the Keynesian and New-Keynesian predictions of a crowding out effect due to an interest rate hike following increased demand. After four years, the effect is nulled out and mean reverts. Although empirical literature offers mixed support for the effects on investment, our estimated impulse response function is similar in form to those found by Blanchard and Perotti (2002) and Mountford and Uhlig (2009) where the negative impact is largest within a year. This could suggest that the ensuing crowding out effect of the interest rate hike on private investment is largest in the early aftermath of a spending shock. Subsequently, this negative effect on private investment is gradually balanced out, which could imply that an offsetting accelerator effect backed by increase aggregate demand manifests itself through the period. However, in contrast to the large negative effects on investment found in some previous studies, our estimated effect is smaller and not statistically significant. As such, any conclusive inference from these estimates should be considered with caution. This is comparable to findings in studies of smaller OECD economies (Perotti, 2005), which could imply that the effects are generally less clear-cut in smaller, open economies than the U.S.

When adding private consumption and investment to the model, we find a more persistent positive effect on GDP following a spending increase. Although the form of our impulse response function is similar to our baseline results, we find a larger initial effect on output where a one-krone spending increases raises GDP by 0.43 kroner on impact. Furthermore, following a drop towards zero after the initial impact, this positive effect stabilizes at a higher level and peaks at 0.60 after five years. This growth in positive effects through the time horizon appear to be carried by the nulling out of an initial negative effect on private consumption and investment. This suggests that an accelerator effect prevails with a lag over this initial crowding out effect. Nonetheless, similar to our results in the three-variable model, the positive effects on output are not statistically significant.

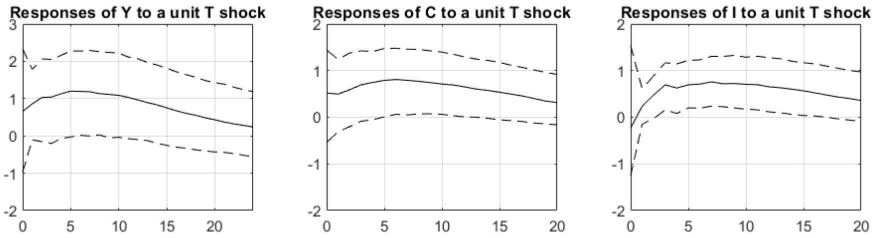

Figure 7.4: Impulse Response Functions following a tax shock. The solid line describe the median impulse responses, while the broken lines represent confidence bands at the 16% and 84% level. G: Government Spending, C: Private Consumption, I: Private Investment, Y: GDP

Table 7.5: Multipliers for a Tax Shock

	1st Quarter	4th Quarter	8th Quarter	12th Quarter	20th Quarter	Peak
GDP	0.65	1.04	1.18	1.03	0.49	1.18 (8)
Consumption	0.52	0.70	0.79*	0.69	0.35	0.79 (8)
Investment	-0.23	0.70*	0.76*	0.70*	0.36	0.76* (8)

Concerning the effects of tax shocks on consumption, both conventional Keynesian and modern DSGE models imply that tax increases cause negative multipliers on consumption. In contrast, we find a positive effect of a tax increase on private consumption with an impact multiplier of 0.52. This positive effect is persistent throughout the time horizon, peaking at 0.79 after two years before gradually decreasing towards the trend. This is counterintuitive, as most theoretical and empirical literature predicts negative effects on private consumption (Ramey, 2016). However, as studies outside of the U.S. have illustrated, the effects of taxes on private consumption are not entirely conclusive, and crowding in effects on consumption are found in e.g. Australia and Germany (Perotti, 2005; Afonso and Sousa, 2009). Moreover, in contrast to the estimated effects of government spending, this counterintuitive effect is statistically significant for a prolonged period, although estimates at longer horizons should be interpreted with caution.

Consistent with theoretical predictions and previous empirical findings, we find that tax increases have an initial negative effect on private investment with an impact multiplier of -0.30. However, this negative effect is short-lived and turns positive from the second quarter onwards, similar to the positive effects on consumption. This positive tax multiplier on investment peaks after two years at 0.76, before gradually decreasing throughout the time horizon. This is unexpected, as estimates of tax effects on investment are primarily negative, although several studies find statistically insignificant multipliers. Nevertheless, a crowding in effect on private investment following tax shocks is found across certain sample periods in Germany and the U.K (Perotti, 2005).

Importantly, our estimated effects on total output are greatly different in the expanded model, and this crowding in effect on both consumption and investment appears to significantly drive up the effect on GDP. In contrast to our baseline analysis, a positive tax shock causes GDP to increase with a relatively large impact multiplier of 0.65, peaking in positive effect after two years at 1.18. Although such positive effects from tax increases are counterintuitive following most theoretical and empirical literature, some studies point to the Expansionary Fiscal Contraction hypothesis, described by e.g. Giavazzi and Pagano (1990). The study finds that, due to the indirect effects on future business cycle expectations, contractive fiscal policy has in fact stimulated growth in GDP across several European countries. In particular, tax increases played an important role in this expansive fiscal consolidation in small, open economies similar to Norway, namely Ireland and Denmark. This could suggest that such crowding in effects on consumption and investment are more likely to be found in smaller, open economies. As such, there could be instances for the Norwegian economy throughout the same period of time in which tax increases have had a crowding in effect on private consumption, driving up effects on output. It must be noted, however, that the positive effects of tax increases found on GDP are not statistically significant and any conclusive inference is limited. Rather, this variation in qualitative and quantitative effects of tax effects in general may suggest that the identification and estimation of effects from tax shocks proves difficult in certain economies. As discussed, the major tax reforms in Norway have primarily aimed at changes to marginal tax rates rather than net tax levels. These tax shocks are not necessarily captured by such an analysis, which could be a factor towards the rather inconclusive results in Norway and other economies alike.

Five-Variable VAR Controlling for Monetary Policy Shocks

Second, as fiscal policy often interacts with monetary policy in affecting the economy, we want to control for monetary policy shocks with respect to the findings in our baseline model. Concerning Norway, monetary policy has replaced some of the role of fiscal policy in stabilization of the economy after the shift to an inflation targeting regime. Hence, monetary policy shocks may influence the effects of fiscal policy on GDP and it is useful to conduct a sensitivity analysis where these shocks are controlled for. To this end, we extend our baseline model to a five-variable VAR model by adding a Mainland GDP deflator and a key interest rate measure (NIBOR), following the methodology of Perotti (2005) and Caldara and Kamps (2008). As the NIBOR interest rate was only available from 1979:Q1 onwards, we conduct the sensitivity analysis controlling for monetary policy shocks from 1979:Q1 to 2017:Q4. This could yield a slight difference with respect to our baseline model, but we consider the analysis reasonable as only four quarters are removed. The five-variable VAR model incorporating monetary policy is constructed as follows:

$$\begin{pmatrix} GDP_t \\ Spending_t \\ Net\ Taxes_t \\ Interest\ Rate_t \\ GDP\ Deflator_t \end{pmatrix} = \begin{pmatrix} B_{11} & B_{12} & \cdots & B_{15} \\ B_{21} & B_{22} & \cdots & B_{25} \\ \vdots & \vdots & \ddots & \vdots \\ B_{51} & B_{52} & \cdots & B_{55} \end{pmatrix} \times \begin{pmatrix} GDP_{t-1} \\ Spending_{t-1} \\ Net\ Taxes_{t-1} \\ Interest\ Rate_{t-1} \\ GDP\ Deflator_{t-1} \end{pmatrix} + \begin{pmatrix} \epsilon_{1,t} \\ \epsilon_{2,t} \\ \epsilon_{3,t} \\ \epsilon_{4,t} \\ \epsilon_{5,t} \end{pmatrix} \tag{7.3}$$

Following Uhlig (2005) and Mountford and Uhlig (2009), a monetary policy shock is identified by a persistent rise in interest rates and a corresponding fall in inflation through four consecutive quarters. Thus, we impose the following sign restrictions in our five-variable VAR:

Table 7.6: Imposed Sign Restrictions Including a Monetary Policy Shock

	GDP	Spending	Net Taxes	Interest Rate	Inflation
Business Cycle Shock	+		+		
Monetary Shock				+	-
Spending Shock		+			
Tax Shock			+		

Note: '+' indicates that the impulse responses are restricted to be positive after a shock. Similarly, '-' restrict the responses to be negative. Lastly, blank fields indicate no restrictions.

When adding inflation and the interest rate to our baseline model, the impulse response functions of GDP (illustrated in Figure 7.5) are similar in form to those found in our baseline model. Thus, our findings are not particularly sensitive to the identification of monetary policy shocks and inclusion of inflation and interest rates. This is consistent with previous literature such as Caldara and Kamps (2008) and Asche and Kristjánsson (2019).

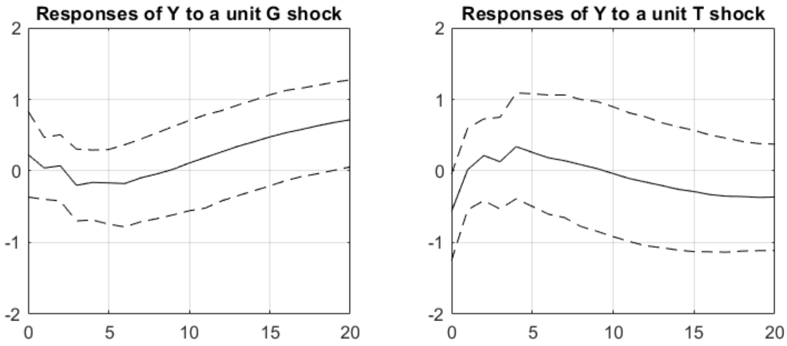

Figure 7.5: Impulse Response Functions following a spending shock (left) and a tax shock (right). The solid lines describe the median impulse responses, while the broken lines represent confidence bands at the 16% and 84% level. G: spending, T: net taxes, Y: GDP.

Concerning spending shocks, the findings approximate those found in our three-variable model, albeit with some quantitative differences as illustrated in Table 7.7 below. On impact, the positive effect on GDP is somewhat larger, where a one-krone spending shock increases GDP by 0.23 kroner. However, similar to our baseline results, this effect is short-lived and turns negative. Moreover, this negative effect of spending shocks is slightly more persistent when accounting for monetary policy shocks. Subsequently, the positive median response grows throughout our time horizon, similar to the findings in our three-variable model, peaking at 0.69 after five years.

The estimated effect of tax shocks on GDP is also similar when controlling for monetary policy. The initial effect is still negative and statistically significant on impact, although slightly smaller with an impact multiplier of -0.57. This could imply that monetary policy shocks capture some of the effects previously found of tax shocks when including inflation and interest rate in the model. This negative effect is also the trough of the tax multiplier, after which the multiplier turns insignificant and temporarily positive. This further reinforces our notion that conclusive inference of tax shocks in Norway is somewhat limited.

Table 7.7: Multipliers When Controlling for Monetary Policy Shock

	1st Quarter	4th Quarter	8th Quarter	12th Quarter	20th Quarter	Peak
GDP - Spending Shock	0.23	-0.20	-0.01	0.19	0.69	0.69 (20)
GDP - Tax Shock	-0.57*	0.13	0.14	-0.11	-0.37 (1)	-0.57* (1)

Subsample Stability

Finally, we test for subsample stability in our baseline model before and after 2001, aiming to test for sensitivity in relation to the implementation of the fiscal rule and inflation targeting. To this end, we split the sample and conduct analyses of a sample ranging from 1978:Q1 to 2000:Q4 and from 2001:Q1 to 2017:Q4.

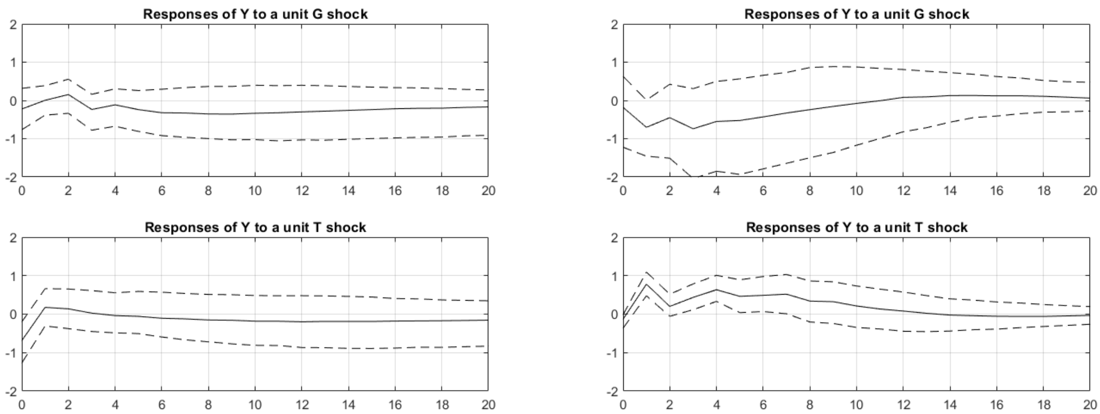

Figure 7.6: Impulse Response Functions of GDP following a spending shock (above) and a tax shock (below). Figures to the left represent the early sample, while figures to the right represent the late sample. The solid lines describe median impulse responses, while the broken lines represent confidence bands at the 16% and 84% levels. G: Government spending, T: Net taxes, Y: GDP

When splitting the data series and analyzing the subsamples, we find that the median responses for spending shocks become smaller and more inconclusive. This is expected, as the subsample split provides a limited amount of observations for the analysis of fiscal shocks. Whereas the spending multiplier is approximating zero for the early sample estimates, the counterintuitive negative effect on output from a positive spending shock is larger for the late sample than in our baseline model. None of the samples display the growing, positive effect found on output in the full sample. Nevertheless, the spending multipliers estimated from the subsamples are not significant throughout the time horizon.

Concerning tax shocks, the impulse response function found in the early sample approximates our baseline findings to a larger extent. After a significant, negative effect on impact, the effect turns insignificant and ambiguous throughout the time horizon. Conversely, when estimating tax effects in the late sample, the impact multiplier is virtually zero before affecting GDP positively. This implies that the effects of tax increases may have changed throughout the sample period, becoming procyclical since the changes in policy regimes. However, the diverging effects pre- and post 2001 may rather reinforce the identified challenges of estimating conclusive tax multipliers for Norway.

The findings in our subsample stability analysis appear to be affected by the loss of several degrees of freedom due to the much smaller sample size. An alternative approach to test for subsample stability could be to implement Markov switching models that allows for time-varying effects across the different states of the economy. Auerbach and Gorodnichenko (2012) used a regime-switching model to estimate fiscal multipliers dependent on the state of the economy, finding larger effects in contractions than in expansions. However, these models are computationally challenging to implement with the sign restrictions approach. Hence, the analysis is beyond the scope and time limitations of this master thesis.

7.3 Comparison with Recursive Ordering Approach

To gain further insight regarding the implications of the sign restrictions approach in a small, open economy, we investigate how the empirical estimates of our baseline, three-variable model change when applying a conventional identification strategy. Since Sims (1980), the recursive ordering approach employing a Cholesky decomposition has been widely used to identify monetary and fiscal shocks, becoming the established standard within SVAR models. Blanchard and Perotti (2002) build on this methodology when applying SVAR analysis to fiscal policy, and most ensuing studies have employed exact or modified versions of the approach. Consequently, we find it highly relevant to analyse fiscal shocks through such an identification strategy to assess potential divergences resulting from the sign restrictions approach. Furthermore, several studies argue that the recursive approach and the Blanchard-Perotti approach are intrinsically prone to estimate virtually identical results due to the underlying ordering of shocks to the variables Caldara and Kamps (2008). As such, the analysis through recursive ordering identification facilitates a solid comparative basis with the majority of previous literature.

Some studies argue that when employing the recursive approach, the choice to order spending or tax shocks first could significantly affect the estimates. Nevertheless, we follow Blanchard and Perotti (2002) and run the model with each respective shock ordered first in order to test this. Similar to Blanchard and Perotti (2002), we find that this does not significantly affect the impulse responses. Therefore, we follow the seminal study and order spending first, consistent with other literature employing recursive ordering (Caldara and Kamps, 2008; Kemp, 2020).

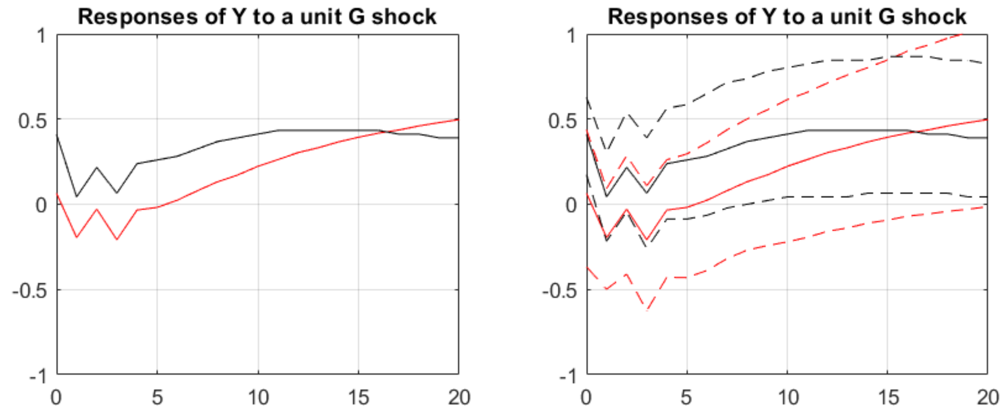

Figure 7.7: Comparison of recursive ordering (black lines) and sign restrictions (red lines) approaches following a spending shock. The solid lines describe median impulse responses, while the broken lines represent confidence bands at the 16% and 84% levels.

Figure 7.7 describes a comparison of the dynamic effects on GDP following a spending shock identified through the recursive and sign restrictions approach, respectively. When identifying government spending shocks through the recursive ordering approach, our findings are qualitatively similar to those with sign restrictions, with some key differences. First, the estimated impact multiplier is substantially larger, implying that a positive spending shock increases GDP by 0.42 kroner on impact. Furthermore, this positive impact multiplier is statistically significant. As illustrated in figure 7.7, the impulse response function mirrors that found through sign restrictions. Following a similar fall in effect approximating zero, the impact multiplier grows positive throughout the time horizon, stabilizing at a multiplier between 0.4 and 0.5 after two years.

Notably, the effects of a positive spending shock on GDP found through recursive ordering is quantitatively very similar to those found by Asche and Kristjánsson (2019), with almost identical multipliers on impact and after two to three years. This is expected, given the similarities in the identification approach applied on both models. This indicates that the sign restrictions approach is the predominant source of divergence with respect to previous findings in Norway, resulting in a significantly lower median impulse response which at times turn negative. Contrary to the findings when employing sign restrictions, these positive effects on GDP are significant from the 8th quarter onwards. This difference in significance when comparing the approaches is expected: in contrast to the strong assumptions imposed by the recursive ordering, a larger variation of results is expected to fit the less rigid sign restrictions. This is further found in previous literature which find wider confidence bands with sign restrictions than with recursive ordering (Caldara and Kamps, 2008; Kemp, 2020).

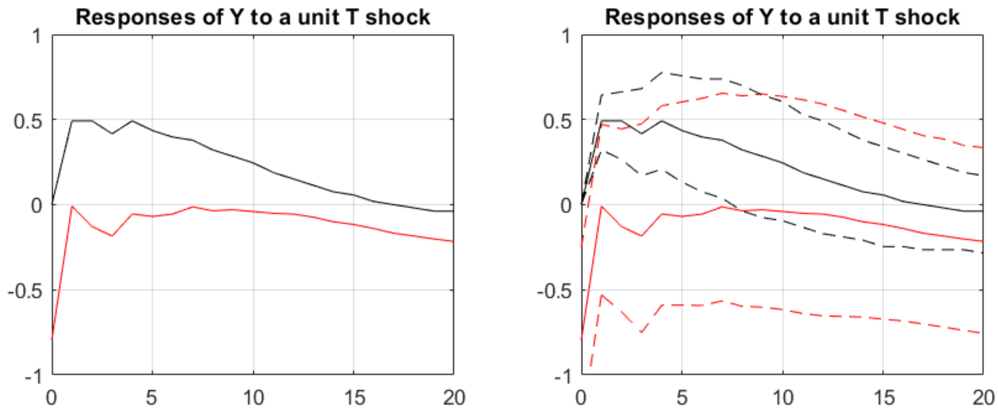

Figure 7.8: Comparison of the Recursive Ordering (black lines) and Sign Restrictions (red lines) approaches following a tax shock. The solid line describe the median impulse responses, while the broken lines represent confidence bands at the 16% and 84% levels.

The effects on output following a tax shock when estimated through the recursive approach are quite different. First, the estimated impact multiplier on output of a positive tax shock is zero. This is due to the approach, as tax shocks are ordered last in the recursive ordering of different shocks. This imposes a zero restriction on the response of output to taxes in the current period, and as such implies a zero effect on impact from tax shocks. In contrast to the negative impact multiplier found with sign restrictions, the effect of a tax increase is now generally estimated to be positive throughout the time horizon. Peaking after five quarters at a tax multiplier of 0.41, this positive effect is persistent until it is nulled out after five years. As discussed, this is unexpected following most theoretical and empirical literature, with the exception of the Expansionary Fiscal Contraction hypothesis (Giavazzi and Pagano, 1990) and some studies outside of the U.S. (Afonso and Sousa, 2009). This positive effect on output is significant from the impact multiplier until the seventh quarter, in contrast to our findings of tax effects through sign restrictions. Thus, the recursive ordering approach induces quite different impulse responses when identifying tax shocks. As discussed above, we find these counterintuitive effects on GDP in our sensitivity analysis when expanding our baseline model. Following our previous discussion on tax shocks, this may rather underline the challenges with estimating tax effects in a small, open economy such as Norway with a limited amount of identified tax shocks.

Discussion of Identification Approach

In general, criticism of the conventional methods building on recursive ordering have been based on two main limitations. First, the recursive ordering implicitly imposes a chain of causation in the model and thus leads the results towards predetermined assumptions. Second, the estimates are highly sensitive to these theoretical assumptions and the calculation of parameters representing structural relationships. In contrast, the sign restrictions approach aims to relieve the analysis of this predetermined chain of causation and large sensitivity to theoretical assumptions as well as externally calculated estimates. Economic relationships may be changing rapidly with frequent changes of fiscal and monetary regimes and large business cycle fluctuations, illustrated by the Great Recession, the Eurozone crisis and the recession induced by the COVID-19 pandemic. In this regard, it is not necessarily reasonable to assume that the parameters representing structural relationships of macroeconomic variables are constant over time. As such, the major advantage of the sign restrictions approach is that it imposes weaker restrictions based on less assumptions, aiming to stay agnostic with respect to contemporaneous relationships. Being less sensitive to the calculation of structural parameters, the sign restrictions approach could be more suited to identify shocks despite changing relationships.

Furthermore, the agnostic aim is more in line with the seminal work of Sims (1980), which pioneered VAR models as a response to conventional, heavy models which some argue rather confirmed their inherent assumptions than estimating true effects (Ramey, 2016). Consequently, an agnostic approach is desirable in an attempt to "let the data speak for itself". This is additionally beneficial when working with high-dimensional VAR models with a large amount of variables, as the sign restrictions utilizing Bayesian techniques may to a larger degree overcome the curse of dimensionality when applying certain priors (Koop and Korobilis, 2010). Nonetheless, employing the sign restrictions approach does come at a cost.

We find that the sign restrictions approach pose certain limitations, which predominantly seem to stem from the less rigid restrictions, as previously discussed. The sign restrictions approach induces substantially larger variation in the estimated effects, resulting in larger confidence bands and less significant multipliers over the time horizons. This, in turn, yields less credibility when extrapolating policy implications for Norway. Although we find a significant, negative tax multiplier on impact when employing sign restrictions, the significance is short-lived and the effects approximate zero. Concerning spending shocks, the initial estimated effect is close to zero and the multipliers are not statistically significant. As more significant effects of spending shocks are found through the recursive ordering approach, this may suggest that identification through sign restrictions is challenging for Norway. Thus, our findings support previous criticism of the sign restrictions approach which argue that the strategy is likely to yield less conclusive results on the effects of structural shocks (Fry and Pagan, 2011).

Furthermore, certain a priori economic assumptions will arguably enter the approach one way or another; for instance, as discussed, we assume that tax changes affect the economy through demand-side channels when analysing government revenue levels. Along these lines, one could argue that the qualitative and quantitative assumptions learned from centuries of economic research should indeed count for something. Evidently, we also impose theoretical assumptions when restricting the direction of impulse responses. In this regard, the results are sensitive to the imposed sign restrictions, the directions of which are not necessarily agreed upon (Uhlig, 2017). Furthermore, as Paustian (2007) notes, one needs to impose sufficient and appropriate restrictions to such analyses to identify any structural shocks. Although our imposed sign restrictions are based on well-established literature, the restrictions are relatively general and may struggle to distinguish between the underlying relationships.

Last, implementation of the sign restrictions approach is computationally complex and has proven to be highly time and resource consuming. The process has been rather challenging given the scope and time limitations of a Master's thesis, through which we have explored several algorithms across multiple software programs. Thus, the computational capacity and time required, in addition to the above limitations, somewhat counteracts the benefits. In Appendix A1, we briefly present challenges related to implementing sign restrictions.

8 Concluding Remarks

This thesis contributes to limited empirical literature concerning the effects of fiscal policy in a small, open economy. The analysis employs the relatively novel sign restrictions approach for identification of fiscal shocks in a Structural Vector Autoregression (SVAR) model of government spending, net taxes and Mainland GDP in Norway. Thus, we provide insight into the effects of fiscal policy and study the suitability of the sign restrictions approach for a small, open economy such as Norway.

We find a small and insignificant positive effect on output (GDP) from government spending shocks. This is unexpected, as theoretical and empirical literature predicts persistent, positive effects on total output. Although inconclusive effects are found in studies of other small, open economies, we do find a significant, positive effect from spending shocks when testing for differences with the more conventional recursive ordering approach. This could suggest that the sign restrictions approach struggles to identify substantial spending shocks in Norway.

On impact, we find a significant, negative effect on GDP following positive tax shocks. This implies that a one-krone tax cut stimulates output by 0.78 kroner within the first quarter, making the case for rapid effects of tax cuts in expansive fiscal policy. However, the tax effect quickly decreases and is not statistically significant after the first quarter. Consequently, similar to previous SVAR literature of Norwegian fiscal policy, we find it hard to conclude on the effects of tax shocks. This notion is reinforced through our sensitivity analysis and the recursive ordering approach, where we find counterintuitive, positive effects on GDP from a tax increase. These inconclusive effects may be due to a limited amount of identified shocks to tax revenue levels, as most tax reforms through our sample period have focused on marginal tax rates.

When expanding the model to a five-variable VAR in our sensitivity analysis, we find negative effects of spending shocks on private consumption and private investment. Furthermore, we find counterintuitive, positive effects from tax increases on both consumption and investment. However, the effects on components of GDP are generally not statistically significant and any conclusive inference is limited. This further underlines the notion that it is hard to conclude on the effects of tax shocks in our sample.

Moreover, we find that the sign restrictions approach for identification provides valuable benefits as well as clear limitations. Mainly, the criticism of conventional methods revolve around the sensitivity of results to internally or externally calculated structural parameters and imposing a clear chain of causation within the model. Conversely, the advantage of the sign restrictions approach is that it imposes weaker restrictions and intends to stay agnostic with respect to the contemporaneous relationships. In doing so, the approach aims to relieve the analysis of a strict chain of causation and sensitivity to changes in structural parameters. Thus, the approach could prove beneficial as structural relationships may be changing frequently following macroeconomic fluctuations and changes to fiscal and monetary regimes.

However, we find that the sign restrictions approach is prone to induce large confidence bands and limited statistical significance in the estimated effects on output. This is an expected consequence of the approach, as a large amount of possible impulse responses are fitted to weak imposed restrictions in the model. As a certain amount of restrictions and assumptions need to be imposed on SVAR models to identify shocks at all, it could be that the approach struggles to identify a limited amount of shocks and estimate the effects in a small, open economy such as Norway. Last, implementation of the sign restrictions approach is computationally complex and has proven to be time and resource consuming.

Further Research

Previous studies have shown that the sign restrictions approach may prove more efficient in larger, multi-variable models, for which we find several additions that could be beneficial for further research. First, an interesting inclusion would be the price of petroleum as an exogenous variable, as fiscal policy and business cycle fluctuations in Norway have been sensitive to its development. Indeed, Bjørnland and Thorsrud (2019) finds a procyclical relationship between the price of petroleum and expansive fiscal policy in Norway. Second, given that tax reforms in Norway more likely cause changes to the structure of taxation rather than tax revenue levels, a study of rates or indices emphasizing marginal tax changes could be valuable. Third, several countries, including Norway, are facing fiscal policy challenges in aging populations and the need for a structural shift from carbon-emitting industries. Thus, there could be an urgent need for innovation stimuli and productivity growth in the economy, motivating an analysis of fiscal policy effects on productivity measures following e.g. Afonso and Sousa (2009). Fourth, it could prove beneficial to study effects of fiscal policy on developments in residential prices and the debt-to-income ratio, which are economic relationships of current concern within monetary and fiscal policy in Norway and other economies. Finally, although the imposed sign restrictions are based upon a well-established theoretical and empirical foundation, it could be argued that there are other reasonable sign restrictions or combinations of sign- and short-run restrictions. The latter is, for instance, explored in studies of monetary policy (Robstad, 2018), and could be a valuable exploration for further research within fiscal policy.

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Appendix

A1 Computational Challenges with Sign Restrictions

The application of sign restrictions in a SVAR model is highly computationally challenging, and the implementation of such an algorithm is beyond the scope and time limitations of a Master's Thesis in Economics. Thus, in order to employ the sign restrictions approach in a SVAR study of fiscal shocks, we had to both find an effective code and an appropriate software in which to apply it. The algorithm was required to be suitable to manipulate for the Norwegian economy and the specific SVAR analysis with a three-variable model and several shocks. In summary, the process of finding and developing a functional algorithm to implement the sign restrictions approach has been highly time- and resource consuming. The process led us through several algorithms across multiple unfamiliar software programs and is described below.

1. GAUSS – Initially, we aimed to employ the original code of Mountford and Uhlig (2009), which is publicly available. However, as the algorithm was written and employed in the unfamiliar software GAUSS, we intended to replicate the code in STATA. This implementation proved difficult, as the code lacked detailed commenting and contained functions not available in STATA.

2. R – Moreover, we tested a sign restrictions-package provided in R, as implemented by Danne (2015). Though the code worked fine and replicated the sign restrictions approach of Uhlig (2005), originally applied on a monetary policy shock, it did not have the feature of implementing several shocks simultaneously. As our analysis aims to study both Tax Shocks and Spending Shocks in a simultaneous ordering, we found it difficult to use for our purpose.

3. RATS – After further research, we found RATS as a potential software for utilization of sign restrictions. A benefit to the program in RATS was available replication files of the original code of Mountford and Uhlig (2009). Translating the replication code worked well, but a difficult interface made tracking potential errors difficult. Importantly, we learned that the algorithm also faced certain criticism in terms of proper draws from the posterior distribution, which arguably made the impulse responses and confidence intervals biased.

Last, as it focused on US data, it proved difficult to alter the code specifications and adapt the code to our Norwegian data.

4. MATLAB – Finally, we tested the use of MATLAB and the recently published code by Breitenlechner et al. (2019), who describe the package ZeroSignVAR. This package takes into account the critique of Mountford and Uhlig (2009), and builds on the algorithm of Arias et al. (2014). The flexibility in adding additional shocks, variables, and imposing restrictions made it easier to adapt to our designated goal, and thus seemed to be the best fit to our assignment.

A2 Data

A2.1 Additional Time Series

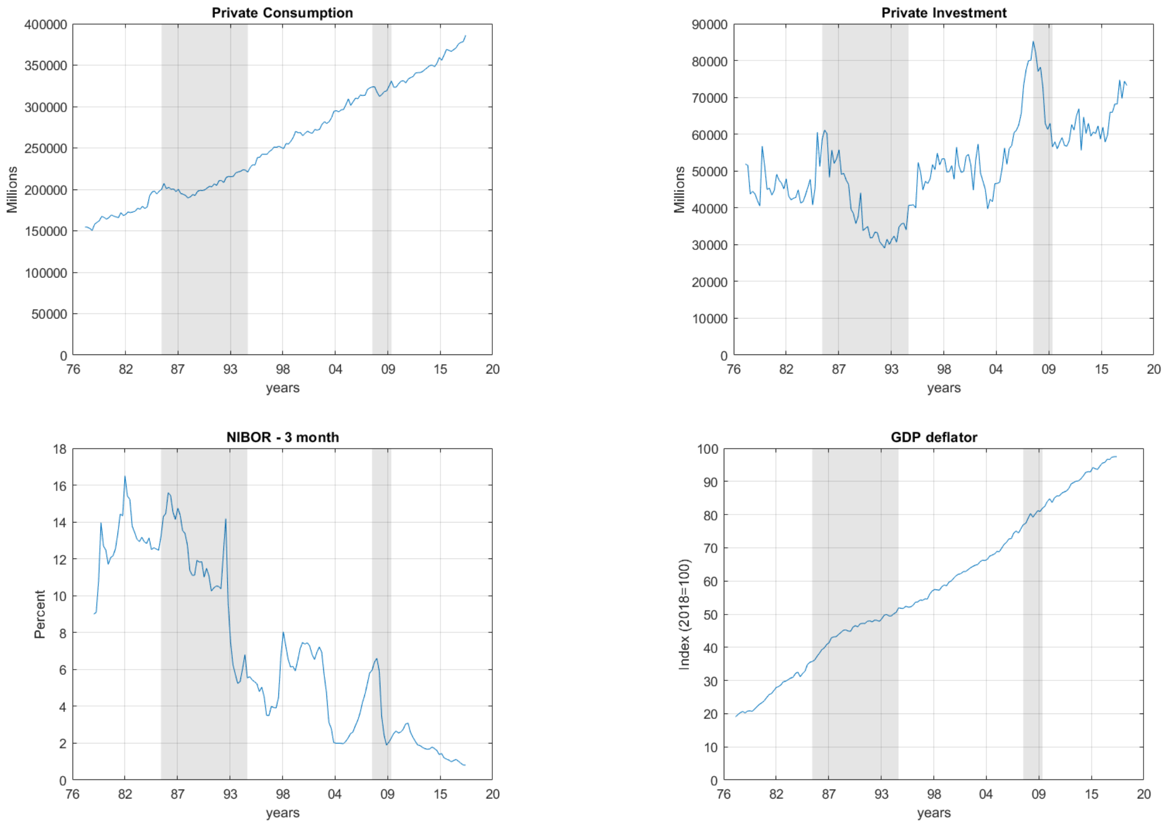


Figure A2.1: Real Values of Private Consumption, Investment, NIBOR rate and GDP deflator with Fixed Prices (2018=100)

A2.2 Seasonally Adjusted Series

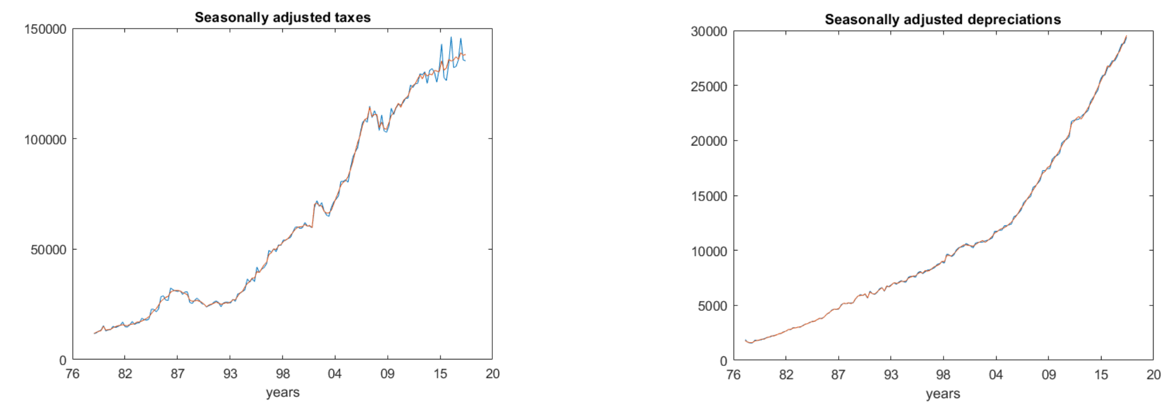


Figure A2.2: Seasonally Adjusted Tax Revenues and Depreciation with X12 Arima

A3 Definition of Variables in VAR models

Mainland GDP: Seasonally adjusted with fixed 2018 prices. Quarterly data from 1978-2017. Retrieved from table: 09190 - National accounts Norway.

Net Taxes: Consists of Government revenue less social transfers, oil revenues, capital income and other transfers. Seasonally adjusted and deflated with GDP deflator to obtain fixed 2018 prices. Quarterly data from 1978-2017. Collected from Minstry of Finance. Retrieved from KVARTS database.

Government Spending: Consists of Government consumption and gross government investment less depreciation. Seasonally adjusted with fixed 2018 prices. Quarterly data from 1978-2017. Retrieved from table: 09190 - National accounts Norway, with the exception of depreciation which were collected from the ministry of finance.

Private Investment: Consists of consumption in households and ideal organisations. Seasonally adjusted with fixed 2018 prices. Quarterly data from 1978-2017. Retrieved from table: 09190 - National accounts Norway

Private Consumption: Consists of gross real investment of Mainland Norway less government investment and residential investment. Seasonally adjusted with fixed 2018 prices. Quarterly data from 1978-2017. Retrieved from table: 09190 - National accounts Norway

Interest Rate: 3 month Norwegian interbank rate (NIBOR). Quarterly percentage data from 1979-2017. Retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/IR3TIB01NOM156N

GDP deflator: Constructed by current and fixed Mainland GDP prices. Quarterly data from 1978-2017. Retrieved from table: 09190 - National accounts Norway.

Population: Retrieved from table 01222 - Population and changes during the quarter. Quarterly data from 1997-2017. Retrieved annually before 1997. We used linearly interpolation in MATLAB to obtain the missing quarterly data.

A4 Recursive Ordering - Baseline Model

A4.1 Spending Shock

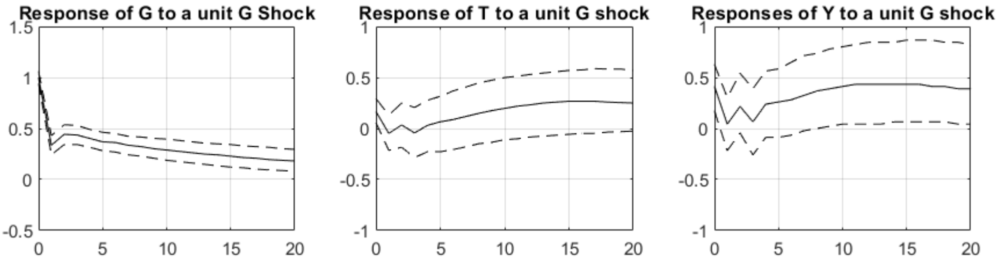


Figure A4.1: Recursive Ordering - Three-Variable VAR - Spending Shock

Table A4.1: Multipliers for a Spending Shock

	1st Quarter	4th Quarter	8th Quarter	12th Quarter	20th Quarter	Peak
GDP	0.41*	0.06	0.32	0.43*	0.39*	0.43* (12)
Spending	1.00*	0.43*	0.36*	0.27*	0.18*	1.00*(1)
Tax	0.16*	-0.04	0.11	0.22	0.25	0.26 (16)
Cumulative	0.41	0.33	0.55	0.71	1.03	1.03 (20)

A4.2 Tax Shock

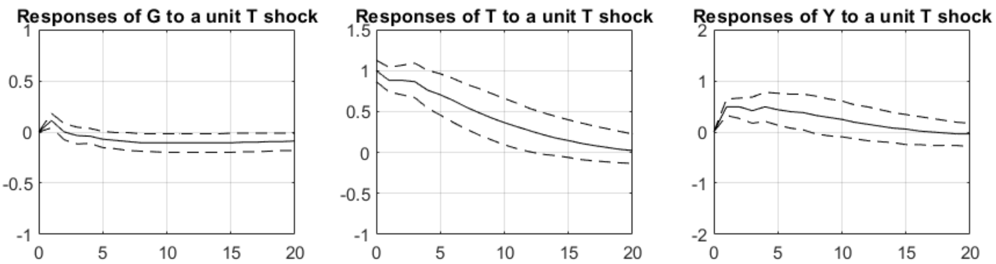


Figure A4.2: Recursive Ordering - Three-Variable VAR - Tax Shock

Table A4.2: Multipliers for a Tax Shock

	1st Quarter	4th Quarter	8th Quarter	12th Quarter	20th Quarter	Peak
GDP	0.00	0.42*	0.38*	0.19	-0.04	0.49* (5)
Spending	0.00	0.04	-0.09	-0.11	-0.09	-0.11(8)
Tax	1.00*	0.87*	0.56*	0.31*	0.04*	1.00* (1)
Cumulative	0.00	0.39	0.49	0.52	0.50	0.52 (12)

A5 Robustness of Baseline Model

Table A5.1: Robustness - Multipliers for Different Model Specifications

	1st Quarter	4th Quarter	8th Quarter	12th Quarter	20th Quarter	Peak
Spending Shock						
2lags	0.10	0.04	0.25	0.39	0.52*	0.52* (20)
6lags	0.10	-0.07	-0.17	0.38	0.65*	0.65* (20)
No Trend	0.07	-0.22	0.10	0.29	0.52*	0.52* (20)
GDP deflated Spending Variable	0.18	-0.18	-0.05	0.31	0.83*	0.83* (20)
Sub sample - Before 2001	-0.22	-0.23	-0.32	-0.32	-0.18	0.35 (9)
Sub sample - After 2001	-0.18	-0.74	-0.24	0.08	0.08	-0.74 (4)
Revenue Shock						
2lags	-0.79*	-0.13	-0.10	-0.08	-0.10	-0.79* (1)
6lags	-0.59*	-0.14	0.20	0.35	-0.20*	-0.59* (1)
No Trend	-0.90*	-0.31	-0.20	-0.25*	-0.38	-0.90* (1)
GDP deflated Spending Variable	-0.53*	-0.23	-0.05*	-0.08	-0.49	-0.53* (1)
Sub sample - Before 2001	-0.69*	0.02	-0.12	-0.18	-0.16	-0.69* (1)
Sub sample - After 2001	-0.13*	0.43	0.51*	0.13	-0.05	0.77* (2)

A6 Test Statistics

Table A6.1: Lag Selection Criteria - Baseline Model

Lag	AIC	HQIC	SBIC
0	-10.38	-10.33	-10.26
1	-15.91	-15.78	-15.61
2	-16.21*	-16.01*	-15.73*
3	-16.18	-15.91	-15.52
4	-16.10	-15.76	-15.26
5	-16.04	-15.63	-15.02
6	-16.02	-15.53	-14.82
7	-15.98	-15.42	-14.59
8	-16.05	-15.41	-14.48
9	-16.07	-15.37	-14.33
10	-15.99	-15.21	-14.07

Table A6.2: ADF Test - GDP

		Log		Log-Difference		
		T-statistic	Probability		T-statistic	Probability
Augmented Dickey-Fuller Test		-0.89	0.96		-5.89	0.00***
Test Critical Values	**1% level**	-4.02		**1% level**	-4.02	
	5% level	-3.44		**5% level**	-3.44	
	10% level	-3.14		**10% level**	-3.14	

Table A6.3: ADF Test - Spending

		Log Transform		Log-Differenced Transform		
		T-statistic	Probability		T-statistic	Probability
Augmented Dickey-Fuller Test		-2.20	0.49		-3.83	0.015**
Test Critical Values	1% level	-4.02		1% level	-4.02	
	5% level	-3.44		5% level	-3.44	
	10% level	-3.14		10% level	-3.14	

Table A6.4: ADF Test - Tax

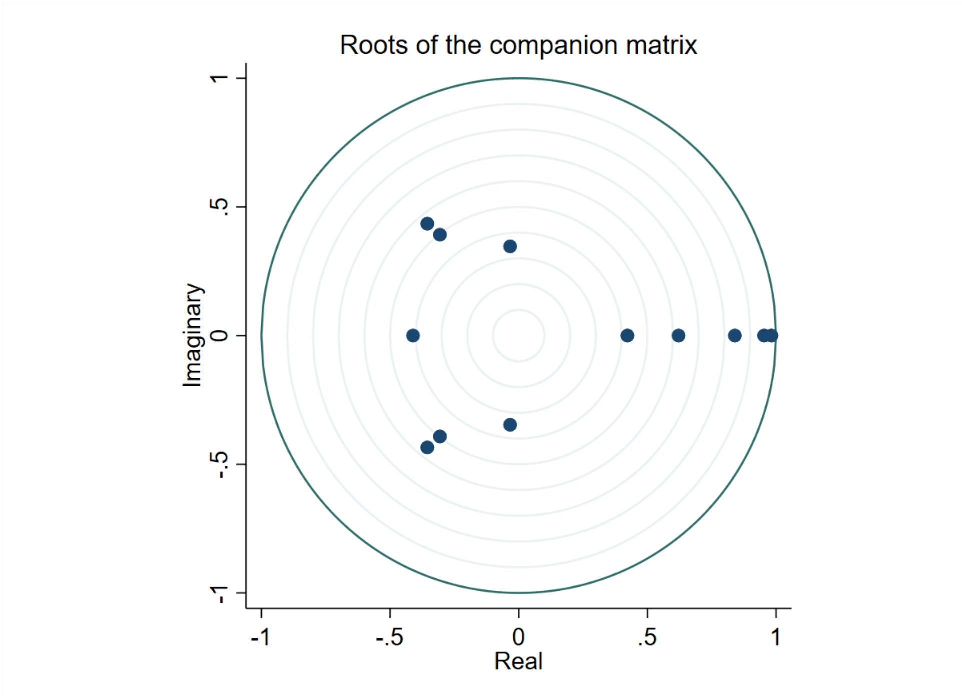
		Log Transform		Log-Differenced Transform		
		T-statistic	Probability		T-statistic	Probability
Augmented Dickey-Fuller Test		-1.94	0.63		-4.262	0.0036***
Test Critical Values	**1% level**	-4.02		**1% level**	-4.02	
	5% level	-3.44		**5% level**	-3.44	
	10% level	-3.14		**10% level**	-3.14	

Table A6.5: Lagrange-Multiplier Test for Baseline Model

lag	chi2	df	Prob >chi2
1	**9.2190**	**9**	**0.41731**
2	**7.1129**	**9**	**0.62537**
3	**13.4676**	**9**	**0.14256**
4	**11.1065**	**9**	**0.26848**

H0: no autocorrelation at lag order

Figure A6.1: Eigenvalue Stability Condition - Baseline Model



All the eigenvalues lie inside the unit circle. VAR satisfies stability condition.