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The Effects of Fiscal Policy in Norway – A SVAR approach

Anne Lene Asche and Arnaldur Sölvi Kristjánsson

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* Takk til Hilde Bjørnland, Thomas von Brasch og andre medlemmer av Finansdepartementets rådgivende utvalg i modell- og metodespørsmål for gode tilbakemeldinger.

Forord

Økonomiske modeller kan benyttes som verktøy for å belyse virkninger av endringer i finanspolitikken. Finansdepartementet bruker Statistisk sentralbyrås makroøkonometriske modeller KVARTS og MODAG til dette formålet, og analysene blir blant annet lagt frem i Nasjonalbudsjettene. De siste 15 årene har det i den internasjonale økonomiske faglitteraturen blitt publisert empiriske anslag for virkningen av finanspolitikken med utgangspunkt i strukturelle vektor-autoregressive (SVAR) modeller. Når man utvikler økonomiske modeller, gjør man normalt forutsetninger om hvordan de ulike variablene i modellen påvirker hverandre, med utgangspunkt i økonomisk teori. Resultatene som kommer ut av modellen må sees i lys av de forutsetningene som er gjort. SVAR-modeller gir færre restriksjoner på strukturen i de empiriske sammenhengene, sammenlignet med andre modelltyper. Resultatene vil dermed kunne sies å være mer datadrevet enn mange andre modeller. Det er gjort få SVAR-analyser av virkningen av finanspolitikken på norske data.

Blanchard og Perotti (2002) var en de første studiene i den empiriske faglitteraturen om virkningen av finanspolitikk. Den er fortsatt en viktig referanse og er derfor et nyttig utgangspunkt for å undersøke hvordan SVAR-metoden kan anvendes på norske data.

Analysen som legges frem i dette notatet følger Blanchard og Perottis beregningsopplegg. Metoden ser ut til å egne seg best til å studere virkningen av endringer i offentlige utgifter, hvor den gir resultater som kan være forenlige med analyser utført på KVARTS og MODAG og med tilsvarende studier basert på data for andre land. I tolkningen av resultatene er det viktig å huske på at de representerer «den gjennomsnittlige virkningen» av «en gjennomsnittlig finanspolitikk» over en lang periode. En skal derfor være varsom med å anvende resultatene direkte på et konkret budsjettopplegg.

For Finansdepartementet er det nyttig at SVAR-metodikken anvendes på norske data fordi det gir et grunnlag for å sammenligne virkninger av endringer i finanspolitikken på norsk økonomi med tilsvarende analyser for andre land. Analysen er gjennomført av Anne Lene Asche (student, NHH) og Arnaldur Sölvi Kristjánsson (Finansdepartementet) som ledd i arbeidet med å styrke departementets metodekunnskap. Et utkast til arbeidsnotatet ble drøftet på møte i Finansdepartementets rådgivende utvalg i modell- og metodespørsmål 28. november 2018.

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Hans Henrik Scheel

Finansråd

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Content

1 Introduction

Following the financial crisis, academics and policymakers around the world turned more attention to fiscal policy as a tool for stabilising economic fluctuations. At the outset, there was a considerable lack of consensus about the effects of fiscal stimulus on the economy. Some economists argued that fiscal stimulus has close to none effect (Barro, 2009), others had the more traditional view that fiscal stimulus would increase output (Romer and Bernstein, 2009), and some even argued that contractionary fiscal policy could be expansionary under some circumstances (Alesina and Ardagna, 2009). This academic disagreement sparked a surge in research on fiscal multipliers in recent years.

The literature mainly relies on two methods to measure fiscal multipliers: model-based estimation[1] and empirical estimations mostly based on structural vector autoregression (SVAR). The fundamental problem of empirical based estimation is to isolate exogenous movements in fiscal variables. We want to distinguish between changes in fiscal policy due to the business cycle (automatic stabilizers and discretionary fiscal policy) and truly exogenous fiscal policy. Three main identification approaches have been applied:

(1) the identification proposed by Blanchard and Perotti (2002),

(2) the narrative variable approach proposed by Ramey and Shapiro (1998) and Romer and Romer (2010),

(3) the sign restriction approach developed by Uhlig (2005) and applied to fiscal policy by Mountford and Uhlig (2009).

There are numerous empirical SVAR studies analysing fiscal policy international data, but few on Norwegian data.[2] In this working paper, we estimate short run fiscal multipliers in Norway based on different specifications using the Blanchard and Perotti methodology. This approach finds an expenditure multiplier in Norway in the lower range of comparable studies, results are however not robust for the tax multiplier.

In section 2 in this report, we review the empirical literature and discuss the main identification strategies. Section 3 describes the methodology by Blanchard and Perotti (2002) in further detail and in section 4, the Blanchard-Perrotti methodology is used to analyse fiscal multipliers in Norway. Section 5 concludes.

[1] On model based approaches, see e.g. Coenen et al. (2012).

[2] To the best of our knowledge, the only studies are the master theses by Lund (2005) and Dinh and Vegard (2018).

2 Literature overview

Structural vector autoregressive (SVAR) models are widely used as a tool to study the effects of fiscal policy measures. The SVAR literature on fiscal policy for the most part focuses on broad measures of fiscal policy and attempts to estimate the size and sign of different multipliers. Typically, these will be how GDP or household consumption responds to changes in government spending or government revenue (an indicator of the tax level). However, there are also studies focusing on other fiscal variables (e.g. the average marginal income tax rate).

Empirical estimates of fiscal multipliers usually reflect the average responses for different time-periods and different fiscal instruments. If the nature and scope of economic policy has changed over time, for example due to changes in the exchange rate regime or broad changes in the composition of spending and taxes, the estimated multipliers might not be representative for current fiscal policy.

It is common to use deviation from trend as identification in SVAR-models. If fiscal policy is stable over time and only changes gradually, most of the variation in the data will be captured by the trend. Deviations from trend may be small, even if the trend can change substantially over a longer period. In this case, it will be difficult to estimate appropriate multipliers.

The main challenge with the SVAR methodology is how to identify the structural fiscal policy shocks. That is, how to isolate exogenous movements in the fiscal variables from endogenous movements. Different methodologies can produce quite different estimates of the size of the fiscal multiplier; hence, the choice of methodology can matter a lot for the result. The most commonly used identification methodologies in the empirical literature is the Blanchard-Perotti identification methodology (or some version of it), the narrative variable approach, and the sign restriction approach. In the paragraphs below, we will provide a short introduction to each method before we discuss some general results in the literature.

2.1 The Blanchard-Perotti approach

Blanchard and Perotti (2002) made the first major contribution to the SVAR-literature on the effect of fiscal policy. Up until then, SVAR models had primarily been used to study the effects of monetary policy. The study by Blanchard and Perotti (2002) has provided a foundation for much of the later literature, both through studies using the same or a similar methodology, and through studies criticizing and attempting to improve it.

Using quarterly US national accounts data from 1960-1997, Blanchard and Perotti study a SVAR model containing variables for GDP, government spending, and net taxes. The major assumption in their approach is that unexpected changes in fiscal variables are due to: (1) the automatic responses of taxes and government spending to unexpected changes in output (automatic stabilizers), (2) discretionary responses of taxes and spending to changes in macroeconomic variables (e.g. fiscal stimulus), and (3) exogenous shifts in taxes and spending (not related to the business cycle), which are the shocks that we wish to identify. Furthermore, Blanchard and Perotti use quarterly data and assume that it takes policymakers more than a quarter to implement discretionary fiscal actions in response to macroeconomic shocks. This implies that there is no discretionary fiscal response within a quarter, i.e. the abovementioned effect (2) can be set to zero. Moreover, they estimate the elasticity of taxes with respect to output outside the SVAR model in order to identify the automatic response of spending and taxes to economic activity, namely point (1) above.

Blanchard and Perotti find that an increase in government spending has a positive effect on GDP while an increase in taxes has a negative effect on GDP. Overall, they find that the spending multiplier is larger than the tax multiplier on impact. The authors also look at the effects of tax and spending shocks on components of GDP. Specifically, they look at consumption, investment, exports and imports. They find that an increase in taxes reduces both consumption and investment, while an increase in spending increases consumption but decreases investment, i.e. public spending crowds out private investment.

There are three main strands of criticism to the Blanchard-Perotti identification. Firstly, it does not take into account anticipation effects. Fiscal shocks are identified based on the time of implementation of the policy, rather than when changes are announced, which might be several periods in advance. If individuals and firms start reacting to aggregate fiscal policy changes at the time of announcement rather than upon implementation, the model might not capture the full effect of fiscal policy shocks (see Barro and Redlick, 2011 and Ramey, 2011a).

Secondly, the effect of a tax shock on output is very sensitive to the tax elasticity of output. As part of the identification approach, an externally calculated tax elasticity is imposed on the system. If this does not correspond to the actual tax elasticity in the underlying data, it might bias the estimated GDP multiplier with regard to change in taxes. According to Mertens and Ravn (2014), the differences in estimates of the tax multiplier in Blanchard-Perotti and narrative variable studies (see below) is largely explained by different estimates of the tax elasticities.

Blanchard and Perotti (2002) construct the tax elasticity of output as a weighted average of elasticities for individual tax categories (see Appendix A for more information). The elasticity for individual tax categories is the product of the elasticity of taxes w.r.t. the corresponding tax base and the elasticity of the tax base w.r.t. GDP. For the personal income tax, the tax base is defined as the product of average earnings and employment. The elasticity is constructed by regressing wages on employment and employment on GDP. The regressions include a lead, 4 lags and the contemporaneous level of the independent variable (employment and GDP), since it is only the effect of current period changes one is interested in. Since the correlation between GDP and the tax base could go both ways, the estimates are potentially biased. This simultaneity problem make the estimates downward biased, according to Mertens and Ravn (2014). The regression does not take into account the possible effects of the tax base on GDP.

Thirdly, the approach aims at measuring the impact of a change in net revenues, defined as taxes minus transfers. This implies that a revenue-neutral tax reform will not be captured, and that an increase in unemployment benefits will have the same effect as a reduction in income taxes. This is clearly unrealistic.[3]

Auerbach and Gorodnichenko estimate the output multiplier using the Blanchard Perotti methodology, but state that they are less confident of the SVAR framework as a tool for measuring the effects of tax policy. They state that “many of the unexpected changes in [taxes] may not arise as a result of a policy change, but rather as a result of a change in the relationship between tax revenues and aggregate activity, and because we would expect the effects of tax policy to work through the structure of taxation (e.g., marginal tax rates) rather than simply through the level of tax revenues” (2012: 6).

2.2 The narrative variable approach

The main idea behind the narrative variable approach is that exogenous fiscal policy shocks are identified by going through budgetary documents and announcements (hence “narrative”). The aim is to identify changes to fiscal policy that are unrelated to other factors affecting current and expected economic development, and therefore can be treated as exogenous. In the existing

[3] In light of these difficulties in measuring the tax elasticity of output, the literature has somewhat gone into other directions for estimating the tax multiplier. Caldara and Kamps call for a “refinement of the way taxes are adjusted for the effects of the business cycle in the structural VAR models” (2008:24). In a SVAR analysis, Perotti does “not study the effects of tax shocks: these are more difficult to identify in a SVAR” (2007 :171).

literature, the narrative variable approach has been used to study the effect of shocks to both government spending and tax revenues.

Studies looking at government spending argue that shocks in military spending caused by foreign political events are easy to isolate from economic activity, and can consequently be appropriate in the construction of a narrative variable (Ramey, 2011a). An important advantage of this approach is that it is possible to create a narrative variable based on when the military spending was announced, and not only when the increase in spending actually occurred. This allows for studying the effects of anticipation, since part of the effect of a fiscal policy shock might occur at the time of announcement, rather than at the time of implantation. In a study on US data, Ramey (2011a) finds that consumers react when learning of an increase in military spending. As mentioned, studies using the Blanchard and Perotti identification approach will not be able to capture these kinds of anticipation effects. However, a drawback with the narrative variable approach is the fact that while increases in military spending are likely to be truly exogenous, it is far from certain that they can be taken to be representative for other government spending shocks. Moreover, the cause for increased military spending, i.e. military conflict, is likely to also affect output directly through other mechanisms.

Another group of narrative variable studies analyse the effect of tax policy shocks. Common to this group of studies is that they go through and estimate the budgetary effects of all legislated tax changes for a given period and classify these as either endogenous or exogenous (Romer and Romer, 2010). Exogenous tax changes are all changes that are not systematically correlated with other developments affecting output, i.e. unrelated to the business cycle. However, the construction of the narrative variable on exogenous tax changes can be time-demanding.

Both the size and the timing of the exogenous tax changes can be taken into account when estimating a narrative tax variable. A common approach is to look at tax changes with less than 90 days between legislation and implementation in order to capture the full effect of tax changes (as this would mean that there should not be any anticipation effects, with quarterly data).

Common for narrative variable studies is that they typically estimate similar or smaller multipliers than Blanchard-Perotti studies at short horizons but much higher multipliers at longer horizons (see also Alesina et al., 2019 and Cloyne, 2011). This demonstrates the important role of the choice of identification strategy in determining the size of the estimated multipliers.

2.3 The sign restriction approach

The third commonly used identification approach for SVARs is to restrict the sign of the effect of a shock on different variables. The main idea of the sign restriction approach is to make assumptions on the sign relationship between the shocks and the shape of the impulse response functions. For example, an expenditure shock is identified as increasing expenditures without simultaneously increasing GDP and taxes. Hence, expenditure shocks and business cycle shocks (identified as a simultaneous increase in GDP and taxes) are uncorrelated. Furthermore, a critical assumption is that movements in the business cycle generate movements in taxes and not the other way around. The approach was originally applied to monetary policy by Uhlig (2005) and first applied to the study of fiscal policy by Mountford and Uhlig (2009).

2.4 Empirical results in the literature

The fiscal multiplier is the ratio of the dollar (or krone) change in output ($\Delta\mathrm{GDP}$) to the dollar change in the fiscal instrument ($\Delta\mathrm{Spending}$ for spending and $-\Delta\mathrm{Tax}$ for taxes), where we consider the effects of stimulating fiscal changes, either a spending increase or a tax cut,

$$\text{Spending multiplier} = \frac{\Delta\mathrm{GDP}}{\Delta\mathrm{Spending}}\,, \qquad \text{Tax multiplier} = \frac{\Delta\mathrm{GDP}}{-\Delta\mathrm{Tax}},$$

where GDP, Spending and Tax are not in logs. The multiplier can therefore be interpreted as the dollar change in GDP versus the dollar change in spending or taxes.

There is a general agreement in the literature on fiscal multipliers that there is no single multiplier as it depends on numerous country specific factors, varies over the business cycle and differs between various fiscal instruments. We will in this section present some of the main findings in the literature.

In a literature review, Hall (2009) finds multipliers based on SVAR estimation in the range 0.5-1. Boussard et al. (2013) finds that the large majority of spending multipliers are in the range of 0.4-1.2 and quite often below 0.7 for tax multipliers. Reviewing a large amount of studies, Mineshima et al. (2014) argue that plausible first year estimates are around 0.5 and 0.9 for government spending and between 0.1 and 0.3 for taxes. Ramey (2019) concludes that spending multipliers lie in the range 0.6-0.8 and tax multipliers peak at 2-3 but often with much lower short run tax multipliers.[4] These surveys are however largely based on US studies.

Blanchard and Perotti (2002) is a starting point for discussion in much of the later literature. Perotti (2004) extends the methodology for a five variable SVAR (GDP, inflation, interest rates, taxes and expenditure) to study the effect of fiscal policy in five OECD countries, while the original study only looked at the US. Perotti found similar results as the original study for the US, but also significant cross-country variation in the size of the fiscal multipliers.

In the short run, spending multipliers are usually larger than tax multipliers since spending has a direct impact on aggregate demand while taxes and transfers only have an indirect effect on demand. For a large number of SVAR studies, the first year spending multiplier is on average 0.8, whereas the tax multiplier is 0.2 (Mineshima et al., 2014). Studies using narrative tax variables and sign restriction approach find much larger peak tax multipliers but in many cases, the multipliers start out low on impact.[5] For example, in Blanchard and Perotti (2002), the tax multiplier is 0.7 in the first quarter, the peak response of GDP is in the fifth quarter and declines thereafter. Whereas Romer and Romer (2010) find that tax cuts have very low and insignificant effect on GDP in the short run but a peak multiplier of nearly 3 around the tenth quarter. This might suggest that incentive effects of tax changes take some time to materialize and also that the narrative studies to a larger degree capture supply side effects (see e.g. Ramey, 2019 and section 4.3).

Several studies have investigated the size of the fiscal multipliers depending on the state of the economy. Many studies find that multipliers are higher during economic recessions and most studies find that multipliers are higher during times of expansionary monetary policy. This may be because in a recession, spending increases are less likely to increase interest rates and crowd out consumption or investment. In addition, the share of liquidity constrained individuals are higher during recessions.

Auerbach and Gorodnichenko (2012) extend the Blanchard-Perotti approach by allowing parameters to vary across the business cycle. In the baseline model, their estimated spending multiplier is 2.2 in recessions and -0.3 in expansions. Subsequent studies have largely confirmed that multipliers are larger during recessions (see e.g. Baum et al., 2012). Some recent studies have reached different conclusions. For example, Owyang et al. (2013) find almost identical multipliers during expansions and recessions for the US, whereas they find much higher multipliers during recessions for Canada (see also Alesina et al., 2017 and 2019). In a review article, Ramey concludes that "there is no clear evidence of higher multipliers during recessions" (2018: 23).

[4] In an earlier review, Ramey (2011b) concludes that the spending multiplier most likely lies between 0.8 and 1.5, but that a wider range also is plausible.

[5] According to Mertens and Ravn (2014), the discrepancy between Blanchard-Perotti type studies and narrative studies is the imposed tax elasticity to output by Blanchard and Perotti (2002) is too low. However, Favero and Giavazzi (2011) and Perotti (2011) argue that the estimated multipliers by Romer and Romer (2010) are upward biased.

While there is a general consensus in the literature that a positive shock in government spending and a negative shock to net taxes increases output, results differ across studies when it comes to the effect of government spending on consumption. Blanchard-Perotti type studies, such as Blanchard and Perotti (2002), Perotti (2004), and Burriel et al. (2010) find that an increase in government spending has a positive effect on consumption. Ramey (2011a) found that an increase in government spending has a negative effect on consumption using the narrative variable approach. The difference could be related to the timing of the shock. The first group of studies analyse the economic effect at the time of implementation of the spending increase, whereas Ramey analyses the effect at the time of announcing the increase, which might be several periods earlier. She finds that consumption declines upon announcement of an increase in government spending and thereafter gradually return (increase) to its steady state level. Blanchard-Perotti studies only capture the latter effect. However, Ramey's study focuses on military spending shocks, which might not be representable for all types of government spending shocks.

In what follows, we will describe the Blanchard and Perotti identification methodology.

3 The Blanchard and Perotti identification methodology

Blanchard and Perotti (2002) analyse a SVAR model containing three variables: the logs of real GDP per capita, real net taxes per capita and real government spending per capita. They use national accounts data where the fiscal variables cover the general government, i.e. federal, state and local governments, and social security funds. Net tax is defined as total tax and non-tax revenues minus transfers and interest payments. Government spending is defined as the sum of government consumption and government investment, excluding transfers. The model is estimated using quarterly US data from 1960-1997.

Formally, the basic VAR specification can be written as

$$X_t = A + \sum_{i=1}^{I} B_i X_{t-i} + U_t, \qquad (1)$$

where the subscript t denotes time, $X_t \equiv (T_t, G_t, Y_t)'$, a vector containing net taxes T_t, government spending G_t, and output Y_t, B_i is a 3x3 coefficient matrix, A is a 3x1 vector of constants which are estimated using OLS. $U_t \equiv (t_t, g_t, y_t)'$ is a vector containing the reduced form residuals and will in general have nonzero cross correlation. The reduced form residuals can be interpreted as unexpected movements in the variable in question, and can be regarded as linear combinations of the underlying structural tax, spending, and GDP shocks. They can be written as

$$t_t = a_1 y_t + a_2 e_t^g + e_t^t,$$
$$g_t = b_1 y_t + b_2 e_t^t + e_t^g,$$
$$y_t = c_1 t_t + c_2 g_t + e_t^y,$$

where e_t^t, e_t^g, e_t^y are the structural shocks that we want to identify. For example, t_t is interpreted as an unexpected movement in taxes within a quarter. This can be the result of either the response to an unexpected movement in GDP ($a_1 y_t$), the response to a structural shock to government spending ($a_2 e_t^g$), or a structural shock in taxes (e_t^t). The two other reduced form residuals have an equivalent interpretation. The coefficients c_1 and c_2 estimate the contemporaneous elasticity of tax and spending changes, respectively.

To identify the above system of equations, we need 3 identifying restrictions, since a system with n variables needs $n(n-1)/2$ identifying restrictions. The primary innovation of the Blanchard-Perotti approach is to use institutional information to construct external estimates for the values of a_1 and b_1. These coefficients capture two effects: (1) automatic responses of taxes or government spending to unexpected changes in GDP within the quarter under existing tax rules (the automatic stabilizer), and (2) discretionary adjustment of fiscal policy made as a response to unexpected changes in GDP within the quarter. The identifying assumption of Blanchard-Perotti is that (2) will be zero. That is, there will be no discretionary fiscal policy response within the quarter. The coefficients a_1 and b_1 will therefore only capture automatic response of taxes and government spending to unexpected fluctuations in GDP. The authors argue that this is reasonable since it will normally take more than a quarter for policymakers to first discover fluctuations in economic activity, and then to decide on and implement a suitable fiscal policy response. Note, however, that this assumption relies on the use of quarterly data. If annual data is used, it may be less likely that the assumption will hold.

Blanchard and Perotti argue that the coefficients a_1 and b_1 consequently can be estimated using the elasticities of government spending and net taxes to changes in output. These are obtained using information on features of the tax-transfer system (see further in section 2.1 and appendix A). The value of b_1 is assumed to be zero, since there are no obvious automatic feedback from changes in output to government consumption or investment within a quarter and transfers are excluded from the spending variable. As an average for the whole sample period, they estimate the output elasticity of net taxes of 2.1. That is, an unexpected increase in GDP by 1%, increases net tax revenues by 2.1%.

The estimated values of a_1 is used to construct cyclically adjusted reduced form residuals for net taxes and government spending. These are defined as

$$t_t' \equiv t_t - a_1 y_t = a_2 e_t^g + e_t^t,$$
$$g_t' \equiv g_t - b_1 y_t = g_t = b_2 e_t^t + e_t^g,$$

which are linear combinations of the fiscal policy shocks. The cyclically adjusted residuals may still be correlated with each other, but are no longer correlated with structural shocks to GDP. They can consequently be used as instruments to estimate c_1 and c_2.

Thus, the only unknown coefficients in the system will be a_2 and b_2. These are estimated based on the basic principle of recursive ordering, where only one variable is allowed to contemporaneously react to changes in the other. In other words, the restriction requires that either $a_2 = 0$ and $b_2 \neq 0$, or vice versa. Blanchard and Perotti argue that there is no theoretically justified way to choose which variable should be allowed to react contemporaneously to changes in the other variable, and consequently run the model twice, once for each possible ordering. Blanchard and Perotti (2002) estimated their model with both types of specification; results were virtually identical in both cases. In the analysis presented in the next section, we also get nearly identical results for both types of specifications. Following Blanchard and Perotti (2002), we focus on the specification with $a_2 \neq 0$ and $b_2 = 0$.

4 Fiscal multipliers for Norway

A central part of the public debate about fiscal policy in Norway has been about the use of revenues from petroleum exploration. These revenues are large, fluctuating, and difficult to forecast. Since 1992 oil revenues are transferred in their entirety to the Government Pension Fund – Global, and the fiscal rule introduced in 2001 stipulates that only the real return of the assets are to be used over the fiscal budget. As more revenues have been transferred to the fund, there has been a gradual increase in the spending of oil revenues and the “non-oil”- budget deficit. The increase in the deficit has not been mechanical, because the rule specifies that fiscal policy shall be used as a tool for stabilising production and employment by managing aggregate demand.

During the last four decades, both the expenditure and tax share of GDP have nevertheless been relatively stable, and similar to the development in the OECD area; see figure 1, which shows the total and adjusted expenditure and tax share. Expenditures to public employment and social transfers have increased relative to GDP, whereas other components such as subsidies have decreased relative to GDP over time. The share of direct taxes have increased slightly whereas the share of indirect taxes and social security contribution have decreased slightly.

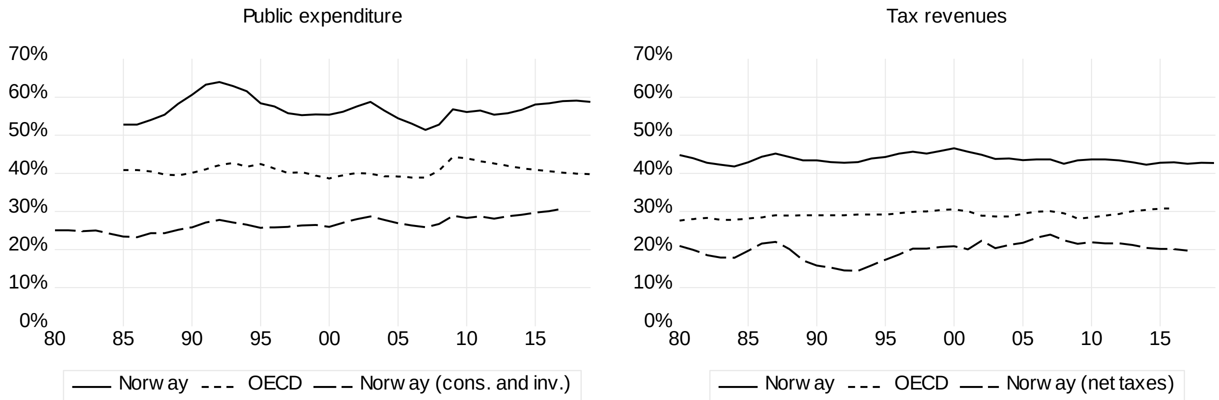

Figure 1: Development of public expenditure and tax revenues as a share of GDP in Norway and the OECD area.

Cons. and inv. is the sum of public consumption and public investment. Net taxes is non-oil revenues less transfers (see further below).
Source: Ministry of Finance (2018).

During the last decades, there have been two big tax reforms in Norway, in 1992 and 2006. The 1992 tax reform followed a general trend in the OECD countries, especially the Nordic countries, to broaden the tax base and lower tax rates. One of the principal objectives of the 2006 tax reform was to achieve more equal treatment of labour and capital income. There are no clear visual effects from the two tax reforms in figure 1, which is not surprising as the main objective of the reforms was to change the structure of taxation, not the tax level.

Total public expenditures as a share of GDP varies over the business cycle whereas the total tax share varies only weakly over the business cycle. Expenditures grow at a fairly stable rate in fixed prices, and as a consequence they increase as a share of GDP during downturns, and fall during upturns. The opposite is the case for taxes. As a result, the expenditure share is countercyclical and the tax share is slightly procyclical. During the whole period, a percentage point increase in the output gap is on average associated with an increase in the tax share by 0.1 percentage point and a decrease in the expenditure share by 1.1 percentage point.

4.1 Data

We define net taxes as the sum of all tax revenues and non-tax revenues. We deduct transfers (to match the Blanchard-Perotti approach), net property income and oil revenues. The exclusion of oil revenues is important in the case of Norway, since revenues from the oil sector go directly into the sovereign wealth fund and the government only makes use of the expected return as defined by the fiscal rule described in the previous section. Transfers include cash transfers to households, subsidies and other transfers (e.g. foreign aid). Government expenditure is the sum of public consumption and investment. In appendix B, we further describes the variables. All data series cover the general government, i.e. the sum of central and local governments. The GDP variable refers to mainland GDP, which excludes petroleum production and shipping.

We use quarterly Norwegian data over the period of 1978:1 – 2017:4. Our baseline model is a three variable VAR model with the logs of real per capita net taxes (T_t), government expenditure (G_t), and mainland GDP (Y_t). The nominal variables are adjusted using their own deflators (for taxes, we use the GDP deflator, as is generally done in the literature), divided by the population size to get variables per capita.[6] All variables are seasonally adjusted.[7]

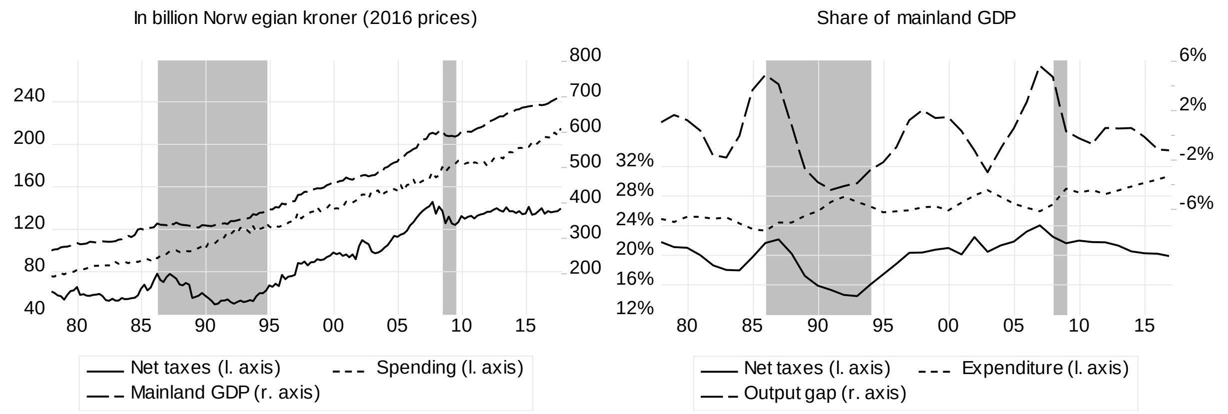

Figure 2: Net taxes, expenditures and output.

Grey areas mark crisis periods. Expenditure the sum of public consumption and public investment. Net taxes is non-oil revenues less transfers and property income.

Figure 2 shows the data that we use in the VAR model, the total net taxes, spending and GDP in fixed prices and seasonally adjusted. In per capita and logs, the series are all non-stationary, but it is not clear whether the variables have a deterministic or a stochastic trend. Public expenditure has a very clear and seemingly linear trend. GDP also has a very clear trend, however with large fluctuations around the banking crisis and international financial crises. Net taxes have a much more irregular trend, which seems stochastic, with large changes around the banking and

[6] Alternatively, we could use the GDP deflator for public expenditure. The results are however very similar. Dividing the variables by population size creates a contemporary correlation in the variables. Importantly though, the structural residuals are uncorrelated .

[7] GDP and expenditure are adjusted by the original source. Taxes and depreciation are not reported seasonally adjusted, we used the X-12 Arima method to seasonally adjust those series.

financial crises.[8] We estimate our VAR with two lags and all variables in levels with both a constant and following the literature we have a linear time trend.[9]

4.2 Blanchard-Perotti methodology for Norway

4.2.1 Estimating a multiplier on net tax revenue

Blanchard and Perotti (2002) use aggregate net tax revenue to estimate the tax multiplier, a measure of changes in the private sector's purchasing power. They make the implicit assumption that fiscal policy mainly works through aggregate demand in the short run, and they also design the model to mainly capture demand effects.[10] The tax shock will be a combination of changes in net taxes that affect incentives (e.g. changes in marginal tax rates) and changes that have small or negligible effects on incentives (e.g. changes in child benefits). Tax changes that have small or no effects on revenues, but potentially large effects on incentives, will not be captured in this approach. This would be the case for e.g. a revenue-neutral tax-reform that lowered marginal income tax rates while increasing VAT. Such reforms could have potentially very large multipliers, if the impact on the economy were large, while the change to revenue were close to zero.

The narrative variable approach by Romer and Romer (2010) identifies tax shocks by using legislated exogenous tax changes, i.e. changes not related to the business cycle. This includes both changes in tax rates and changes in deductions and tax credits. The narrative variable approach might to a larger degree capture supply side effects compared to the Blanchard-Perotti approach (see Ramey, 2019).

Barro and Redlick (2011) use the average marginal income tax rate to estimate the tax multiplier. Thereby they make the implicit assumption that fiscal policy largely works through the supply side. They also analyse whether tax changes mainly work through the demand side or the supply side and conclude that the tax multiplier mainly involves supply side effects.

As described in section 3, the Blanchard-Perotti identification also depends on the output elasticity of net taxes (the tax elasticity), which is estimated outside the SVAR. The elasticity measures the contemporaneous effects of an unexpected output increase on tax revenues. The purpose of the elasticity is to split the relationship between taxes and output into an automatic stabiliser and discretionary fiscal policy. The robustness in the estimated effect of tax changes on output depends on the robustness in the tax elasticity of output.

We estimate the tax elasticity of output (a_1) for Norway following the Blanchard-Perotti procedure. Appendix A describes the construction of the elasticity. The estimated tax elasticity is in the range 0.9 to 1.8, depending on the chosen specification. That is, a 1% unexpected increase in GDP increases net tax revenues between 0.9% and 1.8% within the same quarter. Most studies find elasticities between 1 and 2.

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[8] The visual conjecture is largely confirmed by formal unit root tests. Augmented Dickey-Fuller and Philips-Perron tests indicate that government expenditure has a deterministic trend, net taxes have a stochastic trend and GDP has a stochastic trend, however with a lower significance level.

[9] The residuals show little or no sign of serial correlation. Information criteria (such as AIC and BIC) mostly suggest 2-3 lags, but the difference between the criteria values for different lags is small. This gives a stable VAR, i.e. the effects of shocks in the disturbance eventually die out. Alternatively, we could estimate our VAR using the first difference of all variables, thus allowing for a stochastic trend.

[10] Blanchard and Perotti say that "Any decomposition and choice of two fiscal variables reflects one's theoretical priors. Ours is no exception and reflects our belief that, in the short run, fiscal policy works mainly through the effect of spending and taxes on aggregate demand and the effect of aggregate demand on output. A researcher who viewed fluctuations instead as real business cycles and believed in Ricardian equivalence, would likely choose a different two-variable decomposition, such as government consumption and government investment, or government spending and the marginal tax." (2002: 1332).

As noted by Caldara and Kamps (2008), the tax elasticity can also be estimated endogenously (i.e. inside the SVAR model) based on the Blanchard-Perotti approach by setting $a_2 = 0$, i.e. expenditure shocks do not affect contemporaneous taxes, in order to ensure identification (in addition to setting $b_1 = b_2 = 0$). When the tax elasticity is estimated endogenously, we get $a_1 = 2.9$, much higher than the externally estimated elasticities mentioned above.[11]

Figure 3 shows the impact (first-period) fiscal multiplier for a one-krone negative tax shock and a one-krone positive spending shock (i.e. expansionary shocks) for different values of the tax elasticity of output. First, the figure reveals that the expenditure multiplier is completely invariant to the tax elasticity.[12] Second, the figure shows that our results on the tax multiplier on impact is very sensitive to the value of the estimated tax elasticity. When the elasticity is below two, the tax multiplier is negative. When the elasticity is above two, the tax multiplier is positive. Caldara and Kamps (2008) estimates fiscal multipliers for the US using the Blanchard-Perotti identification. They report a figure analogous to figure 3, with an almost identical shape but with slightly larger multipliers for a given elasticity.

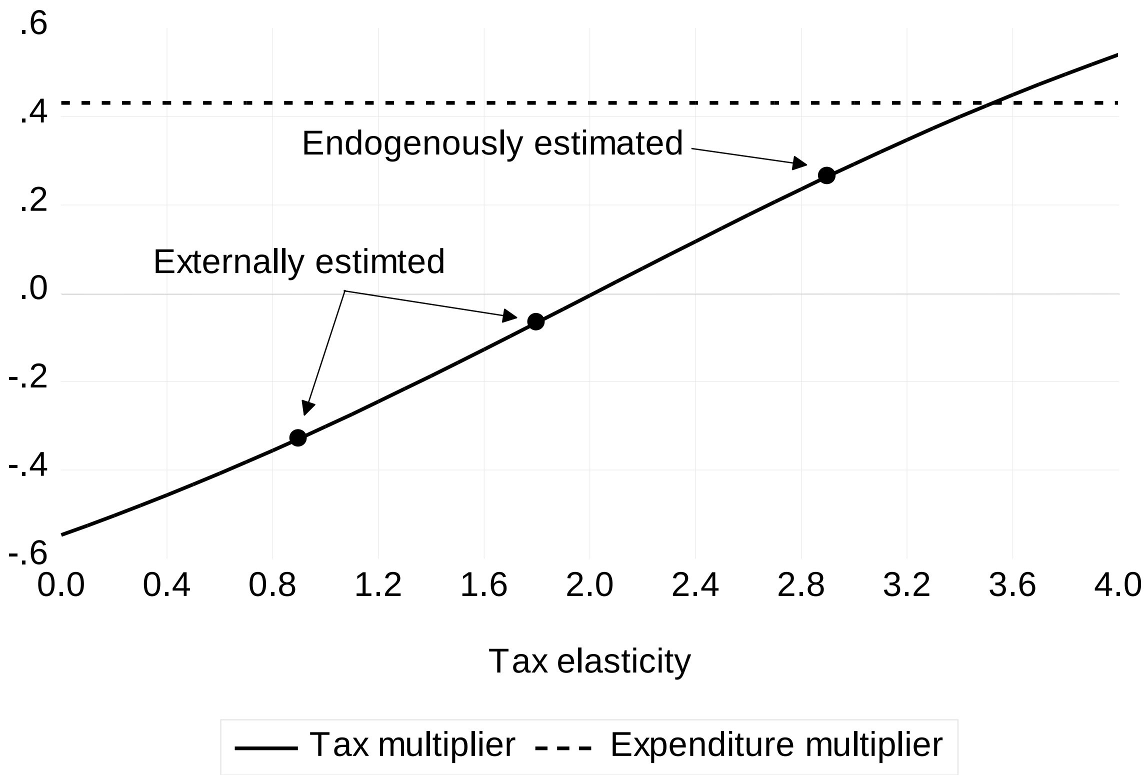

Figure 3: First period fiscal multipliers for different values of the tax elasticity.

The “Externally estimated” observations use output elasticity of net taxes of 0.9 and 1.8, whereas the “Endogenously estimated” observation uses an elasticity of 2.9.

Figure 3 reveals the fundamental weakness of the Blanchard-Perotti identification; the robustness of the tax multiplier depends heavily on the robustness of the estimated tax elasticity of output. For Norway, the estimated tax elasticity (or rather elasticity of net revenue) ranges from 0.9 to

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11 A tax elasticity of 2.9 is considerably larger than externally estimated elasticities in the literature (see e.g. Perotti, 2004). The estimate is however very close to the freely estimated value by Caldara and Kamps (2008), at 3.0, and the internally estimated value using a proxy SVAR by Mertens and Ravn (2014), at 3.1.

12 This follows from the assumption that $b_2 = 0$, with $a_2 = 0$ the expenditure multiplier varies a little with the tax elasticity.

2.9, depending on the chosen estimation method. The corresponding tax multiplier ranges from -0.4 to 0.3, which is in the lower range compared to the general view in the literature, and also not significantly different from zero. The general view in the literature is that the tax multiplier is positive, that is an increase in taxes reduces output.

Since the results on the tax multiplier for Norway are not robust, and, as explained above, the methodology has several weaknesses when it comes to analysing effect of tax changes, we will concentrate on the expenditure multiplier in what follows.

4.2.2 Dynamic effects of expenditure shocks

In what follows, we show the effects of an expenditure shock on the endogenous variables (taxes, expenditures and GDP). We present the krone response of GDP, taxes and spending to a one-krone shock in expenditures.[13] The results are presented in figure 4 and table 1. The solid lines in figure 4 give the point estimates, while the broken lines give the one-standard deviation bands.

In response to a shock in the structural expenditure residual, all variables are affected on impact, thereby also the expenditure variable. A one-krone expenditure shock leads to a roughly one-krone increase in expenditure. The reason is that a one-krone expenditure shock positively affects GDP and net taxes. This leads to a slightly larger expenditure increase than the original shock.

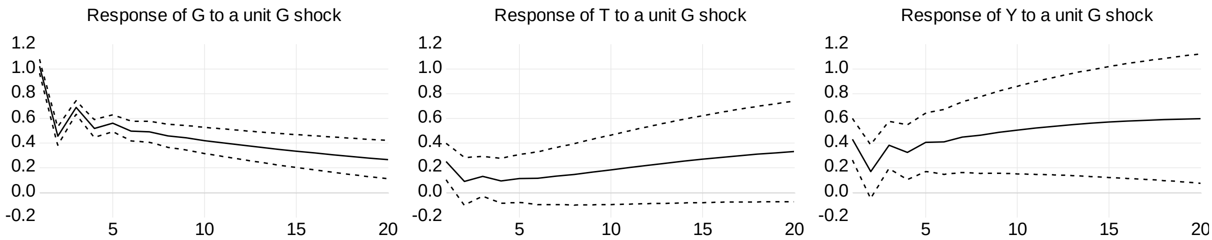

Figure 4: Response to a one-krone expenditure shock.

Broken lines give the one-standard deviation bands. G: expenditure, T: net taxes, Y: GDP.

The expenditure shock increases expenditures by roughly one-krone on impact, and decreases thereafter steadily back to the trend. However, even 5 years after the shock, expenditures are still somewhat higher than without the shock, which means that changes in expenditures are quite persistent for the period under of question (1978-2017).

A positive expenditure shock increases output on impact by 0.4 kroner and stabilises around 0.5-0.6, compared to its pre-shock level, see table 1. However, uncertainty is large which is reflected in the wide confidence bands, especially at longer horizons. With the exception of the first year, GDP increases gradually over time.

The impact expenditure multiplier (the ratio of a change in output to an exogenous change in expenditure within the quarter) is 0.4. From the second quarter onwards, the output response depends on two components. First, the effect of the initial shock, which may last for several

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[13] Following the literature, e.g. Blanchard and Perotti (2002), we use a significance level of 68%. We estimate standard deviation bands using Monte Carlo simulations, based on 500 replications. That is, estimates are significant if the region between the two one-standard deviation error bands is above or below zero.

As is standard in the literature, the impulse response functions are transformations of the original impulse response functions (from logs to levels) by multiplying the impulse response functions with $\sum \exp(X_t)/\sum \exp(G_t)$ for spending and $\sum \exp(X_t)/\sum \exp(T_t)$ for taxes to transform elasticities into multipliers. Ramey (2016 and 2019) argues that this can lead to serious biases if spending and tax share of GDP trend significantly. This is however not the case, as can be seen in figure 1. Another transformation proposed by Gordon and Klemm (2010), which divides all variables with trend GDP (including GDP), avoids the abovementioned problem. Using this approach gives however identical results. Hence, we proceed with the standard approach.

periods as there may be lags in the effects. Second, the persistence of the original shock.[14] A widely used measure is the cumulative multiplier, which takes into account the lagged effects and persistence of the shock. The cumulative multiplier is the cumulative GDP response divided with the cumulative expenditure response at some horizon *n*, $\frac{\sum_{n=1}^{20} \Delta \mathrm{GDP}_n}{\sum_{n=1}^{20} \Delta \mathrm{Spending}_n}$, shown in table 1. Since expenditures decline from the second quarter onward, the cumulative multiplier is higher than the GDP response after the first quarter. The cumulative multiplier is 0.4 at the 1st quarter and increases steadily over time and is 1.1 at the 20th quarter, substantially higher than the GDP response shown in figure 4.

Table 1: Response to a one-krone expenditure shock.

	1st quarter	4th quarter	8th quarter	12th quarter	20th quarter
GDP	0.43*	0.32*	0.46*	0.54*	0.60*
Net taxes	0.25*	0.09	0.15	0.22	0.33
Expenditure	1.02*	0.52*	0.46*	0.38*	0.26*
Cumulative multiplier	0.42*	0.49*	0.65*	0.80*	1.10*

An asterisk indicates significant effects at 68% confidence level.

Net taxes increase in response to the expenditure shock. The increase is however only significant in the first quarter and is not of the same magnitude as the increase in expenditure. That could imply that expenditure shocks tend to be financed by other sources than taxes in the short run, for example as withdrawals from the oil fund, that have increased in line with the fiscal rule. At longer horizons, an increase in expenditures tends to be reflected in higher net taxes, but there is considerable uncertainty around estimates at these horizons.

Most international studies find similar results regarding the response of taxes to an expenditure shock, namely that expenditure shocks are not financed by taxes in the short run. A notable exception is Burriel et al. (2010), where expenditure shocks are accompanied by a roughly equally high tax increase in the EU.

4.2.3 Alternative specifications for the expenditure multiplier

The spending multiplier is quite robust for different specifications of the SVAR, particularly the impact multiplier but also to a large extent the response at longer horizons, see table 2 for alternative model specifications. The alternative specifications use different methods for calculating the trend and contain different variables.

The first specification in table 2 presents the results from table 1 for comparison. The most common approach is to have variables in levels with a deterministic time trend (either a linear or a quadratic trend), but some authors also present results using differenced data (see e.g. Blanchard and Perotti, 2002). In the second specification in table 2, we have used differenced data. The last three specifications have different endogenous variables in the VAR model. First, we have added oil price, where we have made the identifying assumption that the oil price does not respond to contemporaneous shocks in expenditure, taxes and GDP. The second specification is a simple two variable SVAR and the third is a five variable SVAR, following the specification proposed by Perotti (2004), see appendix D for further description.

[14] Fiscal multipliers estimated from structural models are usually estimated from either a permanent shock (a constant increase in expenditures) or a one-period shock.

Table 2: Expenditure multipliers for a one-krone shock in expenditures.

	1st quarter	4th quarter	8th quarter	12th quarter	20th quarter
BP	0.43*	0.32*	0.46*	0.54*	0.60*
Cumulative multiplier	0.42*	0.49*	0.65*	0.80*	1.10*
BP – stochastic trend[1]	0.44*	0.25	0.26	0.26	0.26
Cumulative multiplier	0.43*	0.43*	0.44*	0.44	0.44
BP – with oil price[2]	0.39	0.18	0.28	0.37	0.47
Cumulative multiplier	0.38	0.36	0.45	0.57	0.83
2 variable VAR[3]	0.45*	0.34*	0.48*	0.57*	0.64*
Cumulative multiplier	0.44*	0.50*	0.65*	0.80*	1.09*
5 variable BP[4]	0.30*	0.30*	0.42*	0.55*	0.73*
Cumulative multiplier	0.30*	0.43*	0.59*	0.78*	1.17*

Notes: BP: Blanchard-Perotti identification. An asterisk indicates significant effects at 68% confidence level.
[1] Variables enter the VAR differenced. [2] The logarithm of oil price is ordered first in the Cholesky decomposition, i.e. oil price is not contemporaneously affected by a shock in the other variables. [3] Expenditure and GDP. Expenditure is ordered before GDP in the Cholesky decomposition, i.e. expenditure is not contemporaneously affected by a GDP shock. [4] Taxes, expenditures, GDP, inflation and 10 year government bond interest rates. See appendix D for further description.

Changing the trend assumptions has no effect on the impact multiplier, but the GDP response at longer horizons is somewhat lower then when using the original Blanchard-Perotti method on our data. In addition to the abovementioned alternatives, we have estimated multipliers in SVAR models with four lags, quadratic trend, seasonal dummies and in a model where we changed the ordering of taxes after expenditure (i.e. assuming $a_2 = 0$ and $b_2 \neq 0$ instead of $a_2 \neq 0$ and $b_2 = 0$). These alternatives only marginally affect the estimated multipliers and the results are therefore not shown.

Adding the oil price in the SVAR has only negligible effects on the expenditure multiplier.[15] In this specification, all the estimates are marginally insignificant.

Since taxes increase much less than expenditures after an expenditure shock, the question is raised whether it is important to control for taxes when estimating the expenditure multiplier. As is shown in table 2, the expenditure multiplier is almost identical in a two variable SVAR, without taxes, and a three variable SVAR including taxes. Brückner and Pappa (2012) reach similar conclusions for five OECD countries, i.e. it is not very important to control for taxes when estimating spending multipliers.

Finally, correcting for long term interest rates, and inflation, as is done in the last specification in table 2, slightly reduces the expenditure multiplier on impact but results are almost identical to the three variable SVAR at longer horizons. The expenditure shock increases inflation and long term rates, the latter effect is however not significant in the 5 variable SVAR shown in table 2.

The general result from table 2 is that the impact spending multiplier is quite robust to different specifications. Estimates are in the range of 0.3-0.5 across specifications. The output response at longer horizons is mostly in line with the three variable Blanchard-Perotti model, with the exception of the model with stochastic trend.

4.3 Comparison with other studies

When comparing with other studies in the SVAR literature, the estimated multipliers for Norway seem to be in the lower range. Mineshima et al. (2014) survey the literature on fiscal multipliers

[15] Bjørnland and Thorsrud (2019) make a distinction between demand and supply side shocks in the oil prices in analysing the effects of oil price changes on fiscal policy in Norway. We do not make such a distinction.

and the average first year expenditure multiplier is 0.8 in SVAR models. They argue that the plausible range for multipliers are 0.5-0.9.

Boug et al. (2017) present fiscal multipliers for Norway based on the large-scale macroeconomic model MODAG. A permanent increase in public consumption has a first year multiplier of 1.0, which increases gradually to 1.6 after eight years, and decreasing thereafter, affecting output mainly through an increase in public employment.

5 Conclusion

The Norwegian fiscal framework builds on the premise that fiscal policy affects the Norwegian economy, and underlines the importance of pursuing a countercyclical fiscal policy that can contribute to stabilising aggregate production and employment. It is therefore important to understand – and quantify – the impact of fiscal policy on the economy. The ministry has previously published a working paper mapping out the transmission channels for fiscal policy (Torvik, 2016).

In this working paper, we present an overview of empirical studies of the short-term fiscal multiplier, and replicate one of the seminal studies on Norwegian data. We investigate the effect of changes in taxes and spending on output in Norway using a structural vector autoregression (SVAR) framework. We follow the identification strategy proposed by Blanchard and Perotti (2002), which has become a point of departure for most of the existing fiscal SVAR literature.

The analysis yields a first period spending multiplier around 0.3-0.5. This is in the lower range compared to studies on other economies. The tax multiplier estimate is much less robust, and covers a wide range of estimates. A possible explanation is that the model analyses the impact of changes to net government revenue, and does not capture the impact of changes in marginal tax rates or in transfer schemes. Hence, supply side effects may not be well captured by this approach as tax changes that have small or no revenue effects will not be well captured.

The SVAR approach has to overcome a number of challenges; in particular it is important to note that fiscal policy is in reality a very heterogeneous instrument. For example, changing tax rates may have very different effects on the economy than changing the pension system. Similarly, the impact of an increase in government purchases of e.g. a military aircraft is likely to be very different from the impact of increased employment in public hospitals.

The fiscal multipliers resulting from SVAR estimates reflect the average responses for different time-periods and different fiscal instruments. They may be interpreted as an “average effect” of the “average policy”. Thus, the multipliers may not be correct estimates of the impact of a specific individual tax or spending changes and may not reflect multipliers in a given conjunctural environment. Therefore, they should be interpreted with caution.

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Appendix A – Constructing the tax elasticity of output

Following Blanchard and Perotti (2002), the contemporaneous elasticity of net taxes to output is calculated as the weighted average of the elasticity of different taxes and transfers

$$a_1 = \sum\nolimits_i \eta_{T_i,B_i}\eta_{B_i,X}\frac{T_i}{T},$$

where a_1, as before, is the within-quarter elasticity of taxes with respect to output, η_{T_i,B_i} is the elasticity of taxes of type i to their tax base, and $\eta_{B_i,X}$ is the elasticity of the tax base to GDP. T_i is the level of a specific tax type, and $T = \sum T_i$. Transfers are included as negative values for T_i. We follow Blanchard-Perotti and consider four different categories of taxes: personal income taxes, social security contributions, corporate income taxes and indirect taxes. Transfers are not broken down in different categories. The elasticity only measures the automatic effect of within-quarter changes in GDP on tax receipts and transfer outlays. It does not contain information on the long run relationship between GDP and tax revenues.

Consider first income taxes on individuals and social security contributions. We start by denoting aggregate tax revenues from the personal income tax as

$$H = \tau(W)W(E)E(Y),$$

where τ is the tax rate, W average earnings, Y is aggregate mainland GDP and E is the number of employed people. Differentiating H w.r.t. Y, we derive, after some manipulation

$$\frac{\partial H}{\partial Y}\frac{Y}{H} = \frac{\partial E}{\partial Y}\frac{Y}{E}\left[1 + \frac{\partial W}{\partial E}\frac{E}{W}\left(1 + \frac{\partial \tau}{\partial W}\frac{W}{\tau}\right)\right],$$

where $1 + \frac{\partial \tau}{\partial W}\frac{W}{\tau}$ is the elasticity of tax revenues per person to average earnings and is calculated by use of the tax schedule. We use estimates from OECD (Girouard and André, 2005: 11), which are 1.5 for income tax and 1.1 for social security contributions. The terms $\frac{\partial E}{\partial Y}\frac{Y}{E}$ and $\frac{\partial W}{\partial E}\frac{E}{W}$ are the elasticities of employment w.r.t. mainland GDP and of earnings w.r.t. employment, respectively. These we estimate by using quarterly national accounts data. Following Blanchard and Perotti (2002), the elasticity $\frac{\partial E}{\partial Y}\frac{Y}{E}$ is obtained by regressing the lags 4 to -1 of log change in GDP (i.e. one lead, the current level and four lags) on log change in employment. The elasticity is the coefficient on lag 0 of log change in GDP. The latter elasticity is obtained from a similar regression of log change in earnings on lags 4 to -1 of log change in employment.

The elasticity of corporate profits is the lag 0 coefficient from a regression of log change in corporate profits on lags 4 to -1 of log change in mainland GDP (in constant prices and seasonally adjusted).

Perotti (2004) however has slightly different setup specifications. He uses log levels of all variables instead of the log change. Otherwise, he follows the same setup of the abovementioned Blanchard and Perotti (2002) identification.

We use number of employed persons (employees and self-employed) for E, aggregate mainland GDP for Y and to estimate W we divide total wages and salaries with E to obtain average earnings. All figures are in constant values and seasonally adjusted. The data series are obtained from the Statistics Norway for the period 1995:1 to 2018:2. For corporate profits, we use quarterly data from the Statistics Norway for 2002:1-2018:2 for non-financial corporations. Unfortunately, there are not reliable quarterly data spanning a longer time horizon for the variables under question.

Table A.1 shows the results for three different specifications. First, all variables in log change as is done in Blanchard and Perotti (2002). Second, all variables in log levels as is done in Perotti (2004). Third, all variables in log levels and including the lagged depended variable as an explanatory variable. Fourth, all variables in log levels adjusted for serial correlation in the residual by modelling the residual as a first order autoregressive model (AR(1)).

All regressions have lags 4 to -1 of the explanatory variable. The elasticity is the coefficient on the lag 0 variable. In the table, we report the coefficient estimates and the t-statistics.

From table A.1, it can be seen that the coefficients differ across specifications, with the exception of the profit to GDP elasticity. Apart from the specification with log-level, the residuals are stationary and show little sign of serial correlation. This illustrates that it is challenging to estimate these elasticities.

Table A.1: Estimated elasticities for various specifications.

	Employment to GDP elasticity	Wages to employment elasticity	Profits to GDP elasticity
Log-difference	0.14	0.23	4.57
t statistics	2.4	1.5	3.6
Log-level	0.07	-0.42	4.87
t statistics	0.3	-1.0	1.2
Log-level with lagged dep. var.	-0.02	0.48	3.77
t statistics	-0.3	1.8	2.3
Log-level with AR(1) residual[1]	0.06	0.27	3.68
t statistics	1.2	1.6	2.9

[1] The residual is modelled as $u_t = \rho u_{t_{t-1}} + e_t$.

Following Blanchard and Perotti (2002) and Perotti (2004), the output elasticity of indirect taxes is assumed equal to one. We also follow these authors in setting the output elasticity of social transfers equal to -0.2, as Perotti (2004) does for Australia, Canada, Germany, UK and USA.[16] Finally, non-tax revenues are assumed to have a zero output elasticity.

Using the average share of the components of net taxes for the period 1978-2017, we obtain an elasticity of 0.9 using the results from log-level specification in table A.1 and we obtain 1.8 using the specification log difference in table A.1.[17] That is, we estimate fiscal multipliers using an elasticity of net taxes to GDP of 0.9 and 1.8.

[16] As for the tax components, we just want to capture the within quarter elasticity. The largest share of social transfers goes to pensions, which is not very sensitive to the business cycle. Other components have a much stronger business cycle component, such as unemployment benefits.

[17] In the second specification (log-level), all coefficients are set to zero since they are all insignificant. In the first specification (log-difference), we use the coefficients shown in the table. However, the coefficient for the elasticity wages to employment is only significant at the 13% significance level.

Appendix B – Data definitions and sources

Mainland GDP and Public expenditure (public consumption plus public investment minus depreciation) are obtained from the national accounts from the Statistics Norway statbank. Net tax revenue is retrieved from the KVARTS database from Statistics Norway.

Statistics Norway constructs quarterly tax data from annual data, using the quarterly pattern for the relevant tax bases. For example, the quarterly pattern for labour income tax is based on the quarterly distribution of labour costs. This means that the data on net taxes are an approximation. For the period 1978:1-2001:4 we only have annual data on social transfers whereas we have quarterly data for 2002:1-2017:4. We estimate the quarterly pattern in social transfers for 2002:1-2017:4 by regressing log transfers on a constant, a linear trend and quarterly dummies. We use these quarterly dummies to construct the quarterly observations from the annual data for 1978-2001. That is, we assume that the quarterly pattern of social transfers is the same in 1978-2001 and 2002-2017. From 1997:4 Statistics Norway has quarterly population data, before that we linearly interpolate the annual population data retrieved from the Statistics Norway statbank.

Table A.2 shows construction of the net tax and public expenditure variables. Available information on total public revenue from the Statistics Norway statbank include administrative fees and sales of goods and services, those figures are therefore correspondingly higher. All figures are on accrual basis.

Table A.2: List of variables for net tax and expenditure variables. Annual figures (2017).

	In million NOK		Share of net income
(1) Total public revenues (inntekter i alt)	1 691 624		306 %
(2) Social transfers (stønader til private konsumenter)	489 776		89 %
(3) Other transfers	155 338		28 %
Transfers abroad (overføringer til utlandet)		29 027	5 %
Subsidies (subsidier)		69 422	13 %
Transfer to non-profit organizations (overføring til ideelle organisasjoner)		55 494	10 %
Other Transfers from public administration (andre overf. fra offentlig forvaltning)		1 395	0 %
(4) Oil revenues	204 230		37 %
Interest income and dividends (renteinntekter og aksjeutbytte)		20 396	4 %
Oil taxes (oljeskatter)		97 136	18 %
Transfer from public companies (overføring fra offentlig forretningsvirksomhet)		86 698	16 %
(5) Capital income	290 236		53 %
Interest income and dividends (renteinntekter og aksjeutbytte)		271 695	49 %
Transfer from the central bank (overføring fra Norges Bank)		17 726	3 %
Transfer from public companies (overføring fra offentlig forretningsvirksomhet)		815	0 %
Net taxes = (1)-(2)-(3)-(4)-(5)	**552 045**		**100 %**
(a) Public consumption (offentlig konsum)	797 402		
(b) Depreciation (kapitalslit)	115 229		
(c) Gross public investment (bruttorealinvesteringer)	175 098		
Public expenditure = (a)-(b)+(c)	**857 271**		

Appendix C – Subsample stability of multipliers

Here we show the subsample stability of the expenditure multiplier in the first period. Figure A.1 first shows the multiplier calculated for different periods, which all end in 2017:4 but have a different starting quarter.[18] Second, it shows the multiplier when taking out single quarters in the estimation sample. The solid lines in figure A.1 give the point estimates, while the broken lines give the one-standard deviation bands.

The figure reveals that the first period spending multiplier has been quite stable with the exception of three single quarters that have shifted the multiplier. The observations in 1984:4 and 1991:4 increase the multiplier, whereas observation 1997:2 decreases the multiplier. When we estimate the multiplier for the whole period and either set a dummy for quarters 1984:4 and 1991:4 and 1997:2, or leave them out in our estimation, the multiplier is not affected. That is, the positive effect from the quarters 1984:4 and 1991:4 and the negative effect from 1997:2 cancel out.

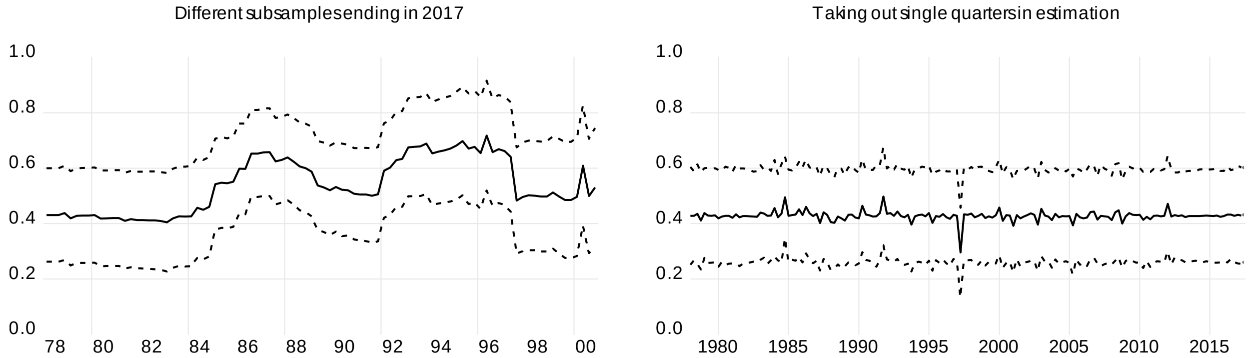

Figure A.1: Subsample stability of expenditure multiplier.

On the left figure, the date on the x-axis refers to the first period in the estimation period of the multiplier. Broken lines give the one-standard deviation bands.

[18] The first observation is the multiplier for the period 1978:1-2017:4, the second for 1978:2-2017:4 etc., all the way to 2000:4-2017:4.

Appendix D – The Perotti (2004) five variable SVAR identification

Perotti (2004) starts out with the same reduced form VAR model as in (1), except that $X_t \equiv (G_t, T_t, Y_t, P_t, I_t)'$ and U_t now have five variables instead of three. P_t is the GDP deflator inflation rate of the price level and i_t is the 10 year interest rate. All variables, except the interest rate, are seasonally adjusted, by either their original source or using the X-12 method. U_t again denotes the reduced form residuals and we have

$$
\begin{aligned}
t_t =& \quad a_{ty}y_t + a_{tp}p_t + a_{ti}i_t + b_{tg}e_t^g + e_t^t,\\
g_t =& \quad a_{gy}y_t + a_{gp}p_t + a_{gi}i_t + b_{gt}b_{gt} + e_t^g,\\
y_t =& \quad a_{yg}g_t + a_{yt}t_t + e_t^y,\\
p_t =& \quad a_{pg}g_t + a_{py}y_t + a_{pt}t_t + e_t^p,\\
i_t =& \quad a_{ig}g_t + a_{iy}y_t + a_{ip}p_t + a_{it}t_t + e_t^i,
\end{aligned}
$$

where e_t^t and e_t^g are the structural shocks to respectively net taxes and government spending. These are again part of a vector of mutually uncorrelated structural shocks denoted $E_t \equiv (e_t^g, e_t^t, e_t^y, e_t^p, e_t^i)'$. Again, the reduced form residual for net taxes can be interpreted as changes in net taxes due to a response to changes in output, a response to changes in the price level, a response to changes in the 10 year interest rate, a response to a structural shock in government spending, or a structural shock to net taxes.

We follow the method by Perotti (2004) to estimate the price elasticity of revenue (a_{tp}) and get an estimate of 1.9. Following Perotti (2004), we set the inflation elasticity of government spending (a_{gp}) equal to -0.5, arguing that public wages decline in real terms following a sudden inflation increase. In addition, we set $a_{gi} = a_{ti} = 0$, since interest payments are excluded from our definition of expenditures and revenues and as before, we set $a_{gy} = b_{gt} = 0$. Our estimated expenditure multiplier does not depend on the value of a_{ty}, hence the value will not be of importance as we do not estimate the tax multiplier for this method. For further description of the method, see Perotti (2004).