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The Interaction Between Fiscal and Monetary Policies: Evidence from Sweden*

Sebastian Ankargren† and Hovick Shahnazarian‡

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Abstract

This paper estimates the interaction between monetary- and fiscal policy using a structural VAR model with time-varying parameters. For demand and supply shocks, the two policies are estimated to be complementary, while for monetary and fiscal policies shocks the two policies act as substitutes. The budget elasticity varies between 0.3–0.6, indicating that an economic downturn can get a non-negligible negative impact on public finances. The fiscal multiplier is estimated to be stable and higher than one suggesting that fiscal policy can be used to support monetary policy to stabilize the economy in case monetary policy is constrained by the lower effective bound.

Keywords: Fiscal policy, monetary policy, time-varying parameter structural VAR, zero and sign restrictions, Bayesian estimation

JEL codes: C11, C32, E52, E62, E63.

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1 Introduction

The economic-policy frameworks before the financial crisis in 2008–09 were based on an underlying assumption that the business cycle and the rise and fall in the production of goods and services in an economy (generally measured using rise and fall in real inflation-adjusted gross domestic product — GDP) and the long-term production level (potential GDP) are independent of each other. Under such an assumption, the current economic situation has no impact on potential GDP, which instead was believed to be determined by structural factors. Consequently, economic policies have been divided into two independent parts: (i) structural policy to raise potential GDP and reduce equilibrium unemployment, and (ii) stabilization policy to reduce economic downturns. Many economists and policymakers advocated, therefore, that an independent central bank should bear the main responsibility for stabilization policy in a floating exchange rate regime. Economists generally also believed that the natural rate of interest was stable at around 2–3% in normal economic cycles. The natural rate of interest is the real interest rate consistent with stable inflation which at the same time maintains economic growth at its trend rate (potential GDP growth), in the absence of a sudden and unexpected temporary increase or decrease of demand for goods or services (so called demand shocks). An inflation rate around 2 per cent is regarded as a stable inflation rate in many countries, and it is also the level of the inflation target in these countries. Monetary policy was during this period essentially concerned with tracking the natural rate of interest as it was believed to yield the best economic outcome of low and stable inflation in conjunction with balanced economic growth. This means that the economy, normally, via monetary policy, will be stimulated in recessions and tightened in economic booms.

The best way for fiscal policy to support monetary policy in this economic-policy framework was believed to be through the automatic stabilizers while maintaining public confidence concerning the long-term sustainability of public finances. The general government budget balance or net lending, which is the difference between revenues and expenditures, vary with the business cycle and automatically tends to smooth fluctuations in domestic demand. These cyclically sensitive taxes and expenditures are therefore commonly referred to as “automatic stabilizers”. The general belief before the financial crisis was that discretionary fiscal policy has a role to play in normal times by dealing with specific problems that may arise in a recession. Fiscal stabilization policy was considered to be ineffective because households were believed to be rational and forward-looking, meaning that deficit-financed tax reductions or expenditure increases, which raise the disposable incomes of households, will fail to increase private consumption and thus to stimulate aggregate demand: households will realize that their life-time incomes have not increased, as they will have to pay for the deficits through higher taxes in the future (commonly referred to as Ricardian equivalence). Economists were moreover convinced that if the financial market, households and businesses lose their confidence, then fiscal policy measures undertaken for stabilization purposes would not be effective. In addition, it was also believed that the central banks would not be able to maintain price stability if the public finances were considered to not be long-term sustainable. This is due to the historical experience that periods of high inflation were often preceded by periods of less well-managed public finances. Furthermore, there was a mistrust of the ability of the political system to withdraw the fiscal stimulus when it was no longer needed. Some also argued that fiscal stimulus has longer lead times than monetary policy.

Economists have long known that the underlying assumptions behind the economic policy framework before the financial crisis are not fully fulfilled. Deep and prolonged recessions can contribute to lower potential productivity due to, inter alia, decreased investment in real capital and R&D. In addition, unemployment tends to be higher over a long period after a deep recession (so-called hysterisis). Economists were also aware that Ricardian equivalence is built on some critical assumptions, namely that consumers have perfect access to the credit market (which is not the case for all consumers), face the same interest rate on borrowing and lending rate as the government (governments can usually borrow at a lower interest rate), expect to live to pay future taxes (some consumers may think that future generation will have to pay the debt), are forward-looking (given uncertainties, it can be difficult for consumers to foresee economic policy changes), and have full insight into the finances of the government (consumers typically have only a vague idea about the condition of governments' finances). The financial crisis and the experience thereafter was a wake-up call also for the way economists think about stabilization policy. This recent crisis highlighted the problems associated with liquidity traps, which is a collective expression for describing a situation in which consumers choose to avoid bonds and keep their funds in savings because of the prevailing belief that interest rates will soon rise. Because bonds have an inverse relationship to interest rates, many consumers do not want to hold an asset with a price that is expected to decline. Other problems highlighted during the financial crisis was those associated with a credit crunch, which is another collective term for a situation where banks and investors become wary of lending funds to individuals and corporations, because lenders fear bankruptcies or defaults, resulting in higher rates. The liquidity trap, credit crunch and recession of 2008–09 caused interest rates to fall below the inflation rate — causing negative real interest rates. Despite low interest rates and unconventional monetary policy, firms and consumers were unable or unwilling to borrow and therefore low interest rates were not sufficient to stimulate the economy and at the same time increase the inflation rate. The sharp downward revisions of potential GDP in all advanced economies since the outbreak of the financial crisis has therefore contributed to an international debate on the question of whether the demand situation could be more important for the long-term production level, which was not the consensus before the financial crisis. The post-crisis environment has therefore motivated a greater focus on fiscal stabilization policy as one possible way to counteract such a development.

In a recent speech, Jansson (2018), the deputy governor of Sveriges Riksbank pointed out that in a world where the neutral interest rate is low, it is unavoidable that central banks' policy rates are not as effective tools as they were before. He also argued that depending on when the next downturn occurs and how deep it is, there is a risk that monetary policy will not suffice when it comes to counteracting it. He discussed a number of tools that could counteract the next economic downturn. One of those tools is fiscal stabilization policy. He concluded that the prospects for using fiscal policy to counteract an economic downturn are much better nowadays since Sweden has strong public finances and a solid fiscal policy framework. At the same time, he also pointed out that the role that fiscal policy should play is not an uncomplicated question. Research in recent years has highlighted that monetary and fiscal policies always interact to jointly determine aggregate demand and the overall level of prices in the economy.[1]

However, the fiscal policy frameworks within the EU and Sweden put some important constraints on the stabilization responsibility that fiscal policy can take on to help monetary policy to stabilize aggregate demand and the overall level of prices. As a member of the EU, Sweden has committed itself to comply with the rules. The

[1] A point made byLeeper (2016) in his review of the literature. See also e.g. Woodford (2011); Farhi et al. (2013); Correia (2016); Williams (2016); Leeper (2018). These papers propose that fiscal and other policies should take on some of the burden to help sustain economic growth and stability. Furman (2016) described this as "the new view" of fiscal policy. Molteni and Pappa (2017) find that fiscal policy strongly affects the impulse responses to monetary policy shocks through the aggregate demand channel, which is especially relevant for understanding the implications of different policy mixes. We refer the interested reader to this paper for a good survey of the relevant literature within this area. The literature review in Gerba and Hauzenberger (2013) shows that the empirical results are inconclusive, and the identified impact of fiscal stabilization depends strongly on the methodology used, even if the majority of the studies reviewed point at least toward an implicit coordination between monetary and fiscal authorities.

most central rules in the pact is the reference values allowed for the public net lending (which should be at most -3 per cent of GDP) and government debt (60 per cent of GDP). In addition to EU budgetary rules, the fiscal policy framework in Sweden includes a surplus target for general government net lending. Originally the target was 2 per cent of GDP. Following a decision by Eurostat that net lending in the premium pension system should no longer be included in the public sector's net lending, the parliament made a technical downward adjustment of the surplus from 2 to 1 per cent of GDP from 2007 and onwards. The Swedish parliament (Riksdag) has decided that the target for the net lending in the public sector should, from 2019, be one-third of GDP on average over a business cycle. The surplus target is supported by a debt anchor for the general government consolidated gross debt, the "Maastricht debt". The debt anchor is not an operational target in the budget process but is a benchmark for the desired medium-term level of the debt. In the event of deviations of more than 5 per cent of GDP from the debt anchor, the Government has to present a communication to the Riksdag setting out the reasons for the deviation and how the Government intends to deal with it. The fiscal policy framework in Sweden also includes an expenditure ceiling for central government expenditure (excluding interest on the central government debt) and expenditure in the old age pension system, as well as a local government balanced budget requirement.

The main purpose of this paper is essentially to study the interaction between monetary and fiscal policy, and how fiscal policy can support monetary policy to stabilize the economy without jeopardizing the medium-term sustainability of public finances. This is done in two steps. In a first step, this paper adds fiscal policy to a traditional structural macro model and extends it with an optimal budgetary policy rule (Section 2). The theory behind the budgetary policy rule (as well as the extended structural macro model) is summarized in Appendix A. However, this appendix can be skipped without losing the overall message but is recommended for readers interested in the theoretical details behind the policy rules. In a second step, the theoretical model is used to formulate an empirical model with the aim to examine the actual policy interactions over time in Sweden. This is done by estimating the monetary and budgetary policy rules together with different key macroeconomic variables, also taking into account that the estimated relationship between the included variables may have changed over time.[2] Appendix B describes the data used in the empirical

[2]The empirical model used is a structural Bayesian vector autoregressive model (SVAR) with time-varying parameters and stochastic volatility. The empirical part of our paper resembles Klein and Linnemann (2018) and Gerba and Hauzenberger (2013) who use a SVAR with time-varying parameters and sign restrictions to study whether the coordination between fiscal and monetary

model while Appendix C provides a brief description of the econometric framework (including the identification scheme), Appendix D includes additional results using a model with no time variation in the parameters, and Appendix E presents additional figures of the impulse responses. These appendices can also be skipped without losing the main message. The estimated model is used to analyse the interaction between fiscal and monetary policies and their effectiveness in stabilizing the economy over time when the economy is struck by various shocks (Section 3). In Section 4, we use the empirical findings to also discuss the average change which net lending, expressed as a share of GDP, undergoes when the output gap changes by 1 percentage point. It is a summarizing indicator of the medium-term sustainability of public finances (so called budget elasticities). In Section 5, we discuss the estimated ratio of a change in GDP to the change in government spending (so called fiscal multipliers) which is a summarizing indicator of the effectiveness of fiscal policy. Section 6 concludes.

The main finding of the theoretical model is that a budgetary policy rule can be used to illustrate how much discretionary fiscal policy the government can undertake to stabilize output and inflation, given different assumptions, without jeopardizing the medium-term sustainability of the public sector's finances. The empirical model, in turn, suggests that the characteristics of the interaction between fiscal and monetary policies depend on the shocks that strike the economy. For demand and supply shocks the two policies complement each other while for monetary and fiscal policies shocks the two policies act as substitutes. The fiscal multiplier is estimated to be higher than 1 on average, indicating that 1 dollar of government spending leads to an overall increase in national income greater than the initial 1 dollar spent. This estimate is reassuring because it is not obvious that monetary policy can alone take full responsibility for stabilization policy when the next downturn occurs, because monetary policy may still be constrained by its lower effective bound. This is especially important since the estimated budget elasticity indicates that a worsening of the business cycle in such a situation can get a non-negligible negative impact on the medium-term sustainability of public finances. Given these empirical findings, fiscal stabilization policy can be used to stabilize the economy in an effective way in times when monetary policy stabilization alone may not be sufficient because of the lower

policies has changed over time in the US. Galí and Gambetti (2015) use a similar approach to analyse the impact of a monetary policy shock along different phases of the financial cycle and in particular with the presence of asset bubbles. Our empirical model is also closely related to Iiboshi et al. (2018), a work in progress which is not yet published to the best of our knowledge, who apply the zero and sign restrictions method proposed by Arias et al. (2018) to a time-varying parameter VAR. Unlike Iiboshi et al. (2018), we use a theoretical model to guide the enforcement of short-term sign- and zero restrictions.

effective bound. This can be done either by strengthening the automatic stabilizers or by undertaking discretionary fiscal policy actions which supplement the automatic stabilizers.

2 The intuition behind the budgetary policy rule

A government planning to undertake fiscal stabilization policy needs a budgetary rule that can be used as a benchmark to analyse the stabilization policy in a structured way and to guide the policymakers to decide how much discretionary fiscal policy that can be undertaken to stabilize output and inflation, given different assumptions, without jeopardizing the medium-term sustainability of the public finances. Appendix A summarizes the theoretical model behind the budgetary policy rule. To derive such a rule, the government is first assumed to put different weights on three important policy variables, namely the surplus target, the GDP gap and the inflation gap. The sum of the weights multiplied by these policy variables gives a so-called loss function for the government. The government is assumed to minimize this loss function given the state of the business cycle, which means that the government is assumed to keep structural balance close to the surplus target for the general government net lending whilst avoiding large demand and supply disturbances. The solution to this minimization problem, summarized in Equation (1), gives each year's budgetary policy rule that satisfies medium-term objectives for public finances (namely the surplus target) and avoids pro-cyclical fiscal policy.[3] The rule is

$$b_t^P = b^T + \theta_t \bar{y}_t + \left(\frac{\beta^F_{Y,t}}{\theta_t \beta^F_{B,t}} \right) \bar{y}_t + \left(\frac{\beta^F_{\pi,t}}{\theta_t \beta^F_{B,t}} \right) \gamma_t (\pi_t - \pi^T) \tag{1}$$

where b_t^P is the government's budget balance or net lending (which is the government's tax income net of transfers minus its real expenditure and interest payments) as a share of potential GDP, b^T is the surplus target, Y is real GDP, Y^e is potential GDP, $\bar{y}_t = (Y_t - Y_t^e)/Y_t^e$, π is inflation, π^T is the inflation target, $\pi_t - \pi^T$ is the inflation

[3] Chadha and Nolan (2007) show that monetary and fiscal policy rules (such as those derived in Appendix A) give a good representation of US and UK stabilization policies. Boije (2005) presents a budgetary policy rule that resembles the one derived in (1). However, he does not derive the budgetary policy rule from a loss function which makes the interpretation of the coefficients rather imprecise. Neither does he take into account that the government may put some weights on stabilizing inflation. The optimization problem in Appendix A gives in other words a solid theoretical ground for the budgetary policy rule that Boije (2005) presented in his paper.

gap, γ_t is the slope of the Phillips curve capturing how GDP gap influences inflation, θ_t is the budget elasticity indicating the extent to which a change in output gap affects net lending, $\beta^F_{Y,t}$ is the weight that the government puts on stabilizing output, $\beta^F_{\pi,t}$ is the weight that the governments put on stabilizing inflation, and $\beta^F_{B,t}$ is the weight that the government puts on the surplus target. The GDP gap, $\bar{y}_t = (Y_t - Y^e_t)/Y^e_t$, is a measure of the difference between actual output and potential output. The output gap is sometimes used to give a picture of the state of the business cycle. A positive output gap means growth is above the trend rate and is inflationary. A negative output gap means an economic downturn with unemployment.

According to the budgetary policy rule in (1), the actual net lending varies around the surplus target to "automatically" return to the balanced level when the GDP gap is closed, and the inflation gap is closed. The second term on the right-hand side of (1), $\theta_t\bar{y}_t$, captures the aggregated impact of the automatic stabilizers. The third term in (1), $\left(\frac{\beta^F_{Y,t}}{\theta\beta^F_{B,t}}\right)\bar{y}_t$, captures the government's discretionary stabilization policy in case of large demand disturbances. An interesting observation is that the discretionary stabilization policy, in this case, is a function of the weight that the government puts on output fluctuations, the weight that the government puts on the surplus target, and the budget elasticity. This means that if the impact of automatic stabilizers increases, then the government does not need to undertake discretionary fiscal stabilization policy to the same extent. At the same time, if a government attaches great importance to meeting the surplus target, it means that they will put less emphasis on stabilizing output. The last term in (1) captures the government's discretionary stabilization policy in case of deviations from the inflation target (large supply disturbances). It is interesting to notice that the discretionary stabilization policy, in this case, is a function of the weight that the government puts on a large inflation gap, the weight that the government puts on the surplus target, the budget elasticity, and how sensitive inflation is to output fluctuations.

Some would argue that a rule like that provided by Equation (1) is nothing but a reaction function for fiscal policy and that, as such, it would encourage fiscal fine-tuning. We want to emphasize that Equation (1) should not be regarded as a reaction function, since the government's budget balance is not fully controllable by the government. The equation indicates instead what each year's ideal budget balance should be to satisfy the medium-term objective and avoid a pro-cyclical fiscal policy. The budget balance concludes the impact that different fiscal policy measures as well as automatic stabilizers may have on government's income and expenditures. Equation (1) only decomposes the impact of automatic stabilizers and discretionary fiscal measures undertaken to fulfill different targets. It should therefore not be confused with a reaction function for fiscal policy. This is also the reason why we have chosen to call this rule a budgetary policy rule. Moreover, given that the rule is based on a predetermined medium-term objective for the entire public sector (surplus target), it constitutes a restriction for the total public sector rather than a reaction function for the central government.

The budgetary policy rule in (1) is a medium-term rule that is intended to satisfy the medium-term surplus target. However, the budgetary policy rule does not say much about the government budget constraint, which states that the government gross debt ratio (pd) will decrease with net lending

$$pd_{t+1} = pd_t - b^P_{t+1}, \tag{2}$$

where it is assumed for simplicity that nominal GDP growth does not increase as a result of discretionary fiscal policy.

In what follows we will clarify the intuition behind the budgetary policy rule and the government's budget constraint by a simple numerical example (Table 1). Let us assume that the budget elasticity (θ) is equal to 0.45, which means that if the GDP gap goes up by one percentage unit then the government's net lending as a share of GDP will increase by 0.45 percentage units. Moreover, we assume that the government puts the following weights on the surplus target, the output gap and the inflation gap: $\beta^F_{B,t} = 1.5$, $\beta^F_{Y,t} = 0.5$, and $\beta^F_{\pi,t} = 0.5$. This means that the government is assumed to put a proportionally much higher weight on the surplus target than on stabilizing the economy. The slope of the Phillips curve (γ) is moreover assumed to be equal to 0.3, which means that if the GDP gap increases by 1 percentage unit then inflation will increase by 0.3 percentage units. The starting point is that net lending is 0.33 per cent of GDP when the GDP gap is balanced (i.e. that it is precisely on the surplus target, $b^T = 0.33$ or 15 billion SEK) and that the government debt as a share of GDP is 40.8 per cent (which was the actual gross debt ratio at the end of 2017 in Sweden calculated in accordance with the rules in the Maastricht Treaty). The nominal GDP in Sweden was about 4579 billion SEK at the end of 2017.

The fourth column in Table 1 shows the isolated effect of the automatic stabilizers. At a GDP gap of -2 per cent of GDP, the impact of automatic stabilizers on net lending would be -0.9 per cent of GDP (SEK 41 billion). At this level of the GDP gap, the government will undertake additional discretionary stabilization policy measures to stabilize the output gap, amounting to -1.48 per cent of GDP (SEK 68 billion).

Table 1: The public sector's net lending, its decomposition and gross debt given different GDP gaps, Share of GDP, Per cent

GDP gap	Inflation gap	Surplus target	Automatic stabilizers	Discretionary fiscal policy to stabilize: output	inflation	Net lending	Gross debt
-2.0	-0.3	0.33	-0.90	-1.48	-0.13	-2.2	43.0
-1.5	-0.2	0.33	-0.68	-1.11	-0.10	-1.6	42.4
-1.0	-0.2	0.33	-0.45	-0.74	-0.07	-0.9	41.8
-0.5	-0.1	0.33	-0.23	-0.37	-0.03	-0.3	41.1
0.0	0.0	0.33	0.00	0.00	0.00	0.3	40.8
0.5	0.1	0.33	0.23	0.37	0.03	1.0	39.9
1.0	0.2	0.33	0.45	0.74	0.07	1.6	39.3
1.5	0.2	0.33	0.68	1.11	0.10	2.2	38.6
2.0	0.3	0.33	0.90	1.48	0.13	2.8	38.0

Note: It is assumed that $\beta_B^F = 1.5$, $\beta_Y^F = 0.5$, $\beta_\pi^F = 0.5$, $\theta = 0.45$, and $\gamma = 0.3$. The gross debt in Sweden was 40.8 per cent in 2017.

Table 2: The public sector's net lending, its decomposition and gross debt given different GDP gaps, Share of GDP, Per cent

β_Y^F	Inflation β_F^π	Surplus target	Automatic stabilizers	Discretionary fiscal policy to stabilize output	inflation	Net lending	Gross debt
0.1	0.1	0.33	-0.90	-0.30	-0.03	-0.9	41.9
0.2	0.2	0.33	-0.90	-0.59	-0.05	-1.2	42.2
0.3	0.3	0.33	-0.90	-0.89	-0.08	-1.5	42.4
0.4	0.4	0.33	-0.90	-1.19	-0.11	-1.9	42.7
0.5	0.5	0.33	-0.90	-1.48	-0.13	-2.2	42.9

Note: It is assumed that the GDP gap is -2, $\beta_B^F = 1.5$, $\beta_\pi^F = 0.5$, $\theta = 0.45$, and $\gamma = 0.3$.

Moreover, the government will also undertake additional discretionary stabilization policy measures to stabilize the inflation gap, amounting to -0.13 per cent of GDP (SEK 6 billion). In this case, the general government's net lending will be -2.2 per cent. However, if the government puts lower weight on stabilizing output and inflation fluctuations then the size of the discretionary measures that it takes will be lower. This is evident from Table 2 where we assume that the GDP gap is -2 while weights on output gap and inflation gap fluctuate between 0.1 to 0.5. The magnitude of the discretionary policy decreases from 1.61 per cent (SEK 74 billion) to 0.33 (SEK 15 billion).

The budgetary policy rule in (1) in isolation does not say much about the impact discretionary fiscal policies may have on the macro economy and monetary policy and vice versa. The purpose of the next section is, therefore, to quantify these interrelationships in order to draw conclusions about the effectiveness of fiscal stabilization policy.

3 Policy interactions and their impact on the economy

Many authors have estimated the effects of fiscal policy using structural econometric models. There is, however, a two-way causality problem, namely that expansionary fiscal policy affects aggregate demand and production but, at the same time, economic activity affects tax revenue and the government's expenditure. In the data, there is, therefore, a strong positive correlation between tax revenues, the government's expenditure and economic activity. Most likely the positive correlation arises because of reverse causality. The goal with a structural model is to recover the effect of an unanticipated shock to the government's expenditures and taxes. We handle this empirically by a vector autoregressive (VAR) model. This means that one estimates a budgetary policy rule together with dynamic equations for production and other variables. From our derived theoretical model we obtain restrictions that we impose on our empirical model, helping us to obtain estimates of how the variables in our model react to unexpected shocks. We identify a business cycle shock jointly with the other shocks, which is crucial in order to separate automatic effects of output fluctuations from discretionary policy measures.[4]

Against this background, we examine the actual policy interactions in Sweden using our VAR model with time-varying parameters and time-varying error covariance. This time-varying parameter structural VAR (TVP-SVAR) is estimated using Bayesian methods on quarterly data from 1997Q1–2018Q2 using 2 lags (see Appendix C for more details). The main variables that we include are foreign output gap, domestic output gap, inflation gap, real interest rate gap, real exchange rate gap, and net lending gap (see Appendix B). The choice of these variables is based on a three-equation structural macro model: an IS curve, a Phillips curve and an interest rate-based monetary policy rule. These three equations are completed with fiscal policy and extended with a budgetary policy rule for the government. The theoretical relationships between different variables derived in Appendix A are then used to identify different shocks through zero and sign restrictions imposed on the responses of variables to the various shocks. The identification is partial meaning that it is not

[4] A classical reference using this method is Blanchard and Perotti (2002). For the identification strategy the interested reader is referred to Uhlig (2005) and Mountford and Uhlig (2009).

necessary to identify as many fundamental shocks as variables in our model. The TVP-SVAR model allows us to capture structural shifts in the economy.

The extended structural macro model in Appendix A is a simple macro model that only includes the main transmission mechanism of fiscal policy. However, there are other transmissions channels that we need to control for in order to draw adequate conclusions regarding the interaction between fiscal and monetary policies and their combined effect on the economy. We therefore include four variables to control for the self-financing channel of government spending, for the financial accelerator mechanism of fiscal policy, for the confidence channel of fiscal policy, and for the fiscal foresight channel (see Appendix B for further information). First, according to the self-financing channel of government spending, higher government spending may reduce the public debt burden by decreasing the debt-to-GDP ratio. To control for this channel, we include the debt ratio-gap. Second, the financial accelerator mechanism of fiscal policy suggests that an expansive fiscal policy may have an important impact on the financing cost of firms, due to the reduced private sector default risk. In order to control for this channel, we expand the list of variables with the spread gap. Third, following the confidence channel of fiscal policy, it is believed that an expansive fiscal policy is more effective in stimulating economic activity by affecting consumer confidence. In order to also control for this channel, we add the consumer confidence gap to the list of variables. Finally, the fiscal foresight channel establishes that the private sector may anticipate government spending changes and adapt its behaviour even before they are announced. To control for the fiscal foresight channel, we use forecasts by the National Institute of Economic Research concerning the magnitude of the discretionary fiscal policy undertaken by the government.

Initially, we analysed the importance of the interaction between fiscal and monetary policies using the historical decomposition of GDP gap, inflation gap, real interest gap, and net lending gap (which can be provided by the authors upon request). We decomposed the value of these variables for every period of the sample, into its different components, each component being due to one structural shock of the model. This identifies the historical contribution of each shock to the observed data sample. The main finding provided by the decomposition is that monetary and fiscal policy shocks seem to have represented a non-negligible part of the GDP and inflation fluctuations. At the same time, GDP shocks and inflation shocks seem to explain a large part of the fluctuations in both real interest rate and net lending, even if inflation shocks play a more prominent role for monetary policy while GDP shocks play a prominent role for the public sector's net lending. Moreover, fiscal and monetary policy shocks seem to explain fluctuations in both the real interest rate and net lending, pointing to the historical importance of the interaction between these two policies. Finally, the importance of monetary and fiscal policies for each other as well as for GDP and inflation has varied over time.

The results in this paper are mainly derived from analysing impulse response functions. Impulse response functions describe the reaction of the macroeconomic variables in the model, such as the output and inflation gaps, at the time of the shock and over subsequent points in time. We focus the analysis on those shocks that are of main interest for the interaction between fiscal and monetary policies and their impact on output and inflation, namely business cycle (demand), inflation (supply), monetary, and fiscal policy shocks. All other impulse responses can be provided by the authors upon request. Since the empirical model we use to obtain impulse responses is time-varying the model estimates a new set of responses at every quarter in our sample (1997Q3–2018Q2). This means that we get three-dimensional figures depicting the impulse responses over time (Appendix E).[5]

There are two important observations that we particularly want to highlight. First, the magnitude of shocks has evolved over time (Figure 6i–6iv in Appendix E). This means that the estimated time-specific standard deviations of the shocks vary over time. Second, turning to the effect that these shocks have on other variables (Figure 6v–6xvi in Appendix E), a notable time variation is evident also in these impulse response functions. Figure 6viii–6x in Appendix E show that a business cycle shock increases inflation and improves the public sector's net lending through the automatic stabilizers. Monetary policy is at the same time tightened. However, the magnitude of these responses has changed through time, which is related to the fact that the size of the shocks has changed. For business cycle shocks, monetary and fiscal policies seem to complement each other. Figure 6xiv–6xvi in Appendix E reveal that a supply shock initially leads to higher interest rates and improved net lending for the public sector (through the automatic stabilizers) and lower GDP gap. After a few quarters monetary policy is reversed in order to counteract the decline in GDP, resulting in a deterioration in public sector net lending. For supply shocks, the interaction between the two policies has a positive correlation, so we conclude that the two policies are complements. Figure 6v–6vii in Appendix E show that a fiscal policy shock (or a tightening of fiscal policy) decreases output gap while monetary policy becomes

[5]Primiceri (2005) and Gerba and Hauzenberger (2013) report the representative (i.e. median) response for three specific periods. However, given the character of the time variation of the response, the median response may indicate that the responses over time in these three selected periods are stable. It is obvious from the impulses responses that this is not the case.

Table 3: The interaction between monetary and fiscal policies

	Substitutes	Complements
Demand shocks		×
Supply shocks		×
Monetary policy shocks	×	
Fiscal policy shocks	×	

more expansive, thereby increasing the inflation gap. For fiscal policy shocks, the interaction now displays a negative correlation, suggesting that the two policies are substitutes. Figure 6xi–6xiii in Appendix E indicate that a monetary policy shock lowers GDP and inflation while also decreasing net lending. Monetary policy shocks are associated with a negatively correlated interaction, again suggesting that the two policies are substitutes.

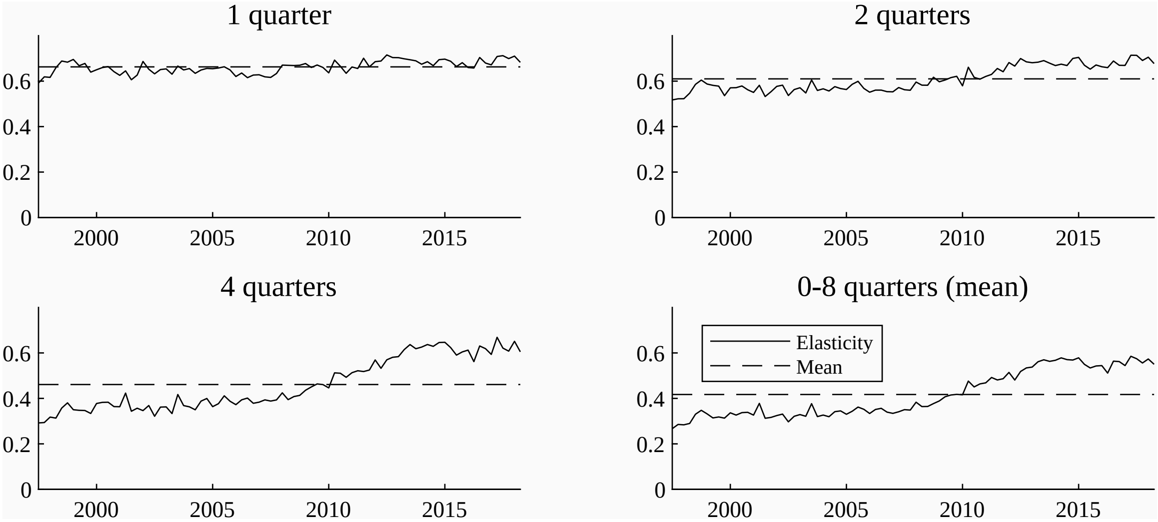
Table 3 summarizes the interaction between fiscal and monetary policies for various shocks that hit the economy. For demand and supply shocks the two policies complement each other while for monetary and fiscal policies the two policies act as substitutes.

The empirical findings in this paper are in line with findings in Muscatelli et al. (2004) who find that for a monetary policy shock, tighter monetary policy results in relaxed fiscal policy, whereby the monetary and fiscal policy are effectively acting as substitutes. Muscatelli et al. (2004) find also that for business cycle shocks, monetary and fiscal policies are complements. Rossi and Zubairy (2011) find that monetary policy shocks are most important for explaining business cycle fluctuations in the short run while fiscal policy shocks are most important over the medium term.

4 Budget elasticity

We use the impulse responses in Figure 6viii to calculate the responses for net lending after one, two, and four quarters as well as the average over a horizon of eight quarters following a demand shock (Figure 1). Figure 1 summarizes the budget elasticity between 1997Q3–2018Q2.

As indicated in Figure 1, the impact that a demand shock has on net lending is high and stable in the first and second quarters after the shock. However, the impulse responses after four quarters have been more volatile through the sample period, ranging from 0.3 to 0.7. This is also the case for the average budget elasticity over a horizon of eight quarters. The median budget elasticity over 1997Q3–2018Q2



Sources: Authors' calculations.
Note: The budget elasticity summarizes the response of net lending gap to a demand shock (that is a shock to GDP gap) after one, two, and four quarters as well as for the average over a horizon of eight quarters.

Figure 1: The budget elasticity

was 0.45 while in 2018Q2 the estimate is 0.6. Most empirical studies that estimate the budget elasticity come to different conclusions regarding the magnitude of the budget elasticity. The literature review by Boije (2004) showed that the estimated budget elasticity for Sweden was 0.7–0.9. The Ministry of Finance (2015) in Sweden uses an average budget elasticity of 0.55 in their calculations of structural balance which they argue is close to the elasticity of 0.59 used by the European Commission. Price et al. (2015) calculations indicate that the elasticity for Sweden is 0.66. The range of the budget elasticity for different countries in their study is 0.21–0.66. The empirical results in this paper are therefore largely in line with the empirical findings in the literature even if the budget elasticity is shown to vary considerably through time. This is an interesting finding since the impact that output fluctuations have on public finances changes depending on prevailing conditions and interrelationships in specific times.

The estimate of the budget elasticity indicates that a worsening of the business cycle in the near feature can get a non-negligible impact on the medium-term sustainability of public finances, especially in a situation where monetary policy is unable to stabilize the business cycle because of the lower effective bound. In Section 3, we showed that fiscal policy can in this specific situation complement monetary policy in stabilizing the economy if it is struck by demand and supply shocks. The question that we will examine in the next section is how effective fiscal policy is as a stabilization policy tool.

5 Fiscal policy multiplier

To answer the question asked in the previous section, we summarize the finding in Figure 6v in a two-dimensional figure by calculating the effect that a fiscal policy shock may have on the GDP gap (Figure 2). We calculate these responses after one, two, and four quarters as well as the average over a horizon of eight quarters following a fiscal policy shock.

The fiscal multiplier (Figure 2) is the effect on the GDP gap from a one percentage unit higher net lending gap. When this multiplier exceeds one, the enhanced effect on national income is called the multiplier effect. The mechanism that can give rise to a multiplier effect is that an initial incremental amount of e.g. spending can lead to increased income and hence increased consumption spending, increasing income further and hence further increasing consumption, etc., resulting in an overall increase in national income greater than the initial incremental amount of spending. As indicated in this Figure 2, fiscal multipliers have been rather stable. The median of the average fiscal multiplier between 1997Q3–2018Q2 is 1.3, indicating that an initial incremental amount of government spending today can lead to increased income. Our empirical findings indicate that the average multiplier has never been below 1 during the entire sample period, suggesting that government spending is estimated to not crowd out private investment or consumer spending that would have otherwise taken place. Such a crowding out can otherwise occur because the initial increase in spending may cause an increase in interest rates or in the price level. In terms of structural methods, a core idea in macroeconomics is that the degree of price rigidity in the economy is a key determinant of the extent to which monetary and fiscal policy affect the economy. If prices are very flexible, a change in demand from some source — say, the government — will induce prices to rise, and this will crowd out demand from other sources. However, if prices are slow to react, this crowd-out does not occur and aggregate demand increases (see e.g. Christiano et al., 2011). The estimated multiplier in this paper suggests that this seems to have been the case for Sweden.

Most empirical studies that study the impact that fiscal policy may have on GDP do find positive effects of increased government spending and tax cuts.[6] The size of

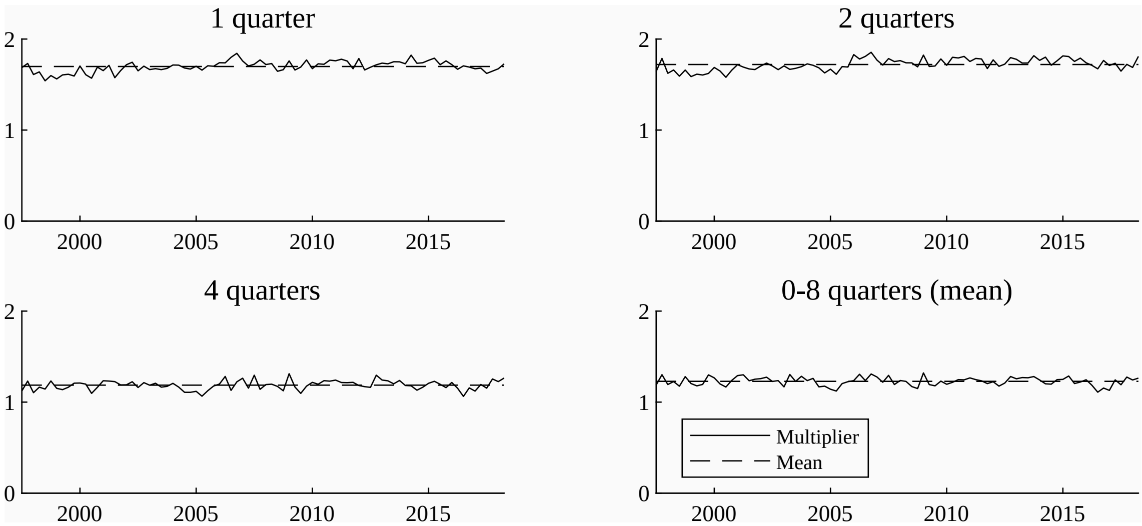
[6]Blanchard and Perotti (2002) and Perotti (2004) found a peak multiplier between 0.9 and 1.3

the multipliers can vary significantly depending on the definition of the fiscal variables, the size of the government, the identification of the structural shocks, the method for estimating impulse responses and fiscal multipliers, for which country or economy the analysis regards, exchange rate regimes, public indebtedness, and the health of the financial system. The empirical literature using non-linear structural VAR models have found that fiscal multipliers are much higher in recessions (around unity for normal times and a peak multiplier between 2 and 3 in recessions). Other papers argue that the government spending multiplier can be very large when the lower effective bound on nominal interest rates binds.[7] The results in this paper indicate that the fiscal multiplier has indeed been higher than unity but considerably stable over time, no matter if times are normal, if the economy is in recession or if monetary policy is constrained by the lower effective bound.

Since it is not obvious that monetary policy alone can take full responsibility for stabilizing the economy when the next downturn occurs, the size of the estimated fiscal multiplier as well as its stability through time is reassuring. This is especially important since the budget elasticity is estimated to be 0.6 in recent times, indicating that a worsening of the business cycle today and in the near feature can lead to a

(depending on specification) for a shock to government spending and a peak multiplier between -0.78 and -1.33 for a shock to taxes. Caldara and Kamps (2017), using different identification strategies in their Bayesian VAR estimations, found similar results for government spending shocks while the results for tax shocks depend on the identification strategy applied. Mountford and Uhlig (2009) use sign restrictions directly on the impulse responses in their VAR analysis. Their largest multiplier is found for a deficit-financed tax cut, with a maximum present value multiplier reaching 5. The overview by Hall (2009) of the literature before 2009 showed that multipliers reach unity or close to unity in most studies, but he couldn't rule out larger values. Klein and Linnemann (2018) estimate the effect of government spending shocks on the US economy with a time-varying parameter vector autoregression and find large impulse responses of output to fiscal shocks during the Great Recession. See also Fatás and Mihov (2001); Ilzetzki et al. (2013); Corsetti et al. (2012).

[7]Auerbach and Gorodnichenko (2012); Owyang et al. (2013); Eggertsson (2011) found that the GDP multiplier for public spending may be 4–8 times higher when the policy rate is on its effective lower bound. For Sweden, Hjelm and Stockhammar (2016) investigate the short-run effect of fiscal policy on GDP and employment using a non-linear approach and found larger multipliers, reaching about 2 after eight quarters for their measures of spending and a multiplier from a tax cut going from 2 to -1 for their measures of taxes. Coenen et al. (2012) found that the size of many multipliers is large, particularly for spending and targeted transfers, subjecting seven structural DSGE models (all used by policymaking institutions) and two prominent academic DSGE models, to discretionary fiscal stimulus shocks using seven different fiscal instruments. Different studies have found that the conduct of monetary policy is of major importance when studying fiscal multipliers (see e.g. Christiano et al. (2011); Miyamoto et al. (2018); Ramey and Zubairy (2018)). Erceg and Lindé (2014) found that the spending multiplier in liquidity traps is much larger than in normal circumstances, and the budgetary costs minimal in case the liquidity trap is very prolonged. However, the multiplier decreases substantially at higher spending levels indicating that it is crucial to distinguish between the marginal and average responses of output and government debt. The interested reader can find interesting results also in Gordon and Krenn (2010); Christiano et al. (2011); Canova et al. (2011); Woodford (2011); Bachmann and Sims (2012).



Sources: Authors' calculations.
Note: The fiscal multiplier is the response of GDP gap to a fiscal policy shock after one, two, and four quarters as well as for the average over a horizon of eight quarters.

Figure 2: The fiscal multiplier

non-negligible impact also on the medium-term sustainability of public finances. The issue of how to stabilize the economy becomes even more pressing in a situation where monetary policy is limited by the lower effective bound and as such is unable to counteract a downturn in the economy. What these empirical findings thus suggest is that fiscal stabilization policy can be used to support monetary policy to stabilize the economy in this specific situation. This can be done either through strengthening the automatic stabilizers or discretionary fiscal policy actions which supplement the automatic stabilizers.

6 Conclusions

The main responsibility for stabilization policy currently lies with many central banks around the world following the introduction of various inflation targets. Inflation has, however, in many places been significantly below the target in recent years. Because of this, central banks have lowered their policy rates to zero per cent or even below-zero levels. Moreover, they have undertaken unconventional monetary policy with large-scale purchases of government bonds with the aim of pushing down the long-term interest rates. In Sweden, the Riksbank had purchased both nominal and real government bonds at a total nominal value of 340 billion SEK, roughly 7% of GDP, at the end of 2018. This strategy has so far been successful as it has contributed to higher GDP growth and inflation, but at the same time, may have contributed to imbalances in the housing and credit markets, which could adversely affect the economy in the future if these imbalances burst. There is at the same time many indications that the current level of the monetary policy rate is close to what is usually called the effective lower bound for the policy rate, since the most recent policy rate cuts have not fully passed through to lending rates that households and companies pay. The central banks have already bought a large share of the outstanding stock of government bonds and different government agencies, as well as market players, have repeatedly pointed out that the central banks' purchases disturb the functioning of the bond markets. Many economists also argue that there is a risk that monetary policy will be limited by the effective lower bound much more often in the future than previously.[8] Recent macroeconomic forecasts are showing that there is a high likelihood that the business cycle will deteriorate over the next few years. The question is how the business cycle should be stabilized in a situation where monetary policy cannot fully take its stabilization responsibility because of the effective lower bound. In this particular situation, fiscal policy will therefore likely need to take a larger responsibility for stabilization if a negative demand or supply shock would hit the economy.

The question is how fiscal policy can shoulder this additional stabilization policy responsibility. In order to answer this question, we have in this paper included fiscal policy in a traditional structural macro model and extended it with an optimal budgetary policy rule. Policymakers can use such a rule to analyse how much discretionary fiscal policy can be undertaken to stabilize output and inflation, given different assumptions, without jeopardizing to deteriorate the public sector's finances.

Given that policymakers decide to undertake discretionary fiscal policies, the next question to be asked is how these policies will interact with monetary policy and what the combined effect of these policies will be for the economy. To be able to address this question, the theoretical model is used to formulate an empirical model with the aim to examine the actual policy interactions over time in Sweden. This is done by estimating the monetary and budgetary policy rules together with different key macroeconomic variables, taking also into account that the estimated relationship

[8]See e.g. Erikson and Vestin (2019) and Eggertson et al. (2019) for recent studies of the incomplete pass through. Sveriges Riksbank (2017) conducted a risk survey in the spring of 2017 with the aim of providing an understanding of how the market players view financial risk and the functioning of the financial market. The report concludes that "[t]he Riksbank's purchases of government bonds are also mentioned as a contributory factor in the deterioration in market liquidity for government bonds". For a discussion concerning the limits of the monetary policy, the interested reader is referred to Williams (2016) and the references therein.

between the included variables may have changed over time. The empirical analysis reveals that both monetary and fiscal policy have stabilizing effects on output. The empirical results also indicate that two policies would complement each other if a negative demand or supply shock would hit the economy. Moreover, fiscal policy is shown to have a multiplier that exceeds one, indicating that 1 dollar of government spending today can result in an overall increase in national income greater than the initial 1 dollar spent. A larger-than-one fiscal multiplier is reassuring, as it implies that fiscal policy can be an effective way to stabilize the economy in times when monetary policy alone may not be sufficient because of the lower effective bound. This is especially important since the estimated budget elasticity indicates that a worsening of the business cycle today and in the near feature can get a non-negligible impact also on the medium-term sustainability of public finances.

The overall conclusion is therefore that fiscal stabilization policy can be used to support monetary policy in its mission to stabilize the economy in this specific situation. This can be done either through strengthening the automatic stabilizers or discretionary fiscal policy actions which supplement the automatic stabilizers. To be effective, stabilization policy must be credible. Experience shows that the nature of the political decision-making process can lead to a weakening of the stabilization policy's credibility. These problems indicate that one should rather reinforce the automatic stabilizers. But it can be politically difficult, for example, to increase the progressivity of income taxes. It is also not certain that these automatic stabilizers are properly adapted to counteract various specific demand and supply shocks. The existing automatic stabilizers may therefore have to be supplemented by various discretionary fiscal measures.[9]

In order to actualize this economic policy recommendation, the barriers within the current fiscal and monetary frameworks should be reviewed and reformed. This concerns primarily the rule that prevents discretionary fiscal stabilization policy actions from being pursued in a normal economic situation, where a normal economic situation is defined to be prevailing as long as the GDP gap is between -1.5 and 1.5 per cent of potential GDP. Another rule concerns the yearly follow-ups of the new debt anchor and whether discretionary fiscal stabilization policy should be regarded

[9]Chadha and Nolan (2007) point out that automatic stabilizers have an important and immediate effect for optimal monetary policy. McKay and Reis (2016) found that the traditional disposable-income channel used to support automatic stabilizers is quantitatively weak. They showed that they play a negligible role in the dynamics of the business cycle, whereas tax-and-transfer programs that affect inequality and social insurance can have a larger effect on aggregate volatility. Moreover, they also found that the stabilizers have a more important role when monetary policy is constrained by the zero lower bound.

as a clear approved cause for why the debt ratio has deviated more than 5 percentage points from the debt anchor of 35 per cent. A review of the current stabilization policy framework should also consider whether the Riksbank, if necessary, should be given the opportunity to ask, in a letter to the parliament, for fiscal support and the extent of the support needed to meet demand and supply shocks.

A fiscal stabilization policy is also more efficient if one takes into account the effect that this policy may have on potential GDP. In other words, there is no clear difference between structural and a stabilizing policy. It is therefore important to pursue a fiscal stabilization policy that actively counteracts lower potential GDP growth following temporary weak demand. However, the empirical model in this paper is estimated using variables in gap terms, which rely to large extent on equilibrium levels of the underlying variables. These equilibriums are non-observable variables which are estimated in a first step. In this paper, potential levels are obtained using either policy targets, the Hodrick-Prescott filter or judgments made by economic institutes. Another way to estimate these non-observable variables would be to use semi-structural state-space models in which the long-term filtering of variables is conducted jointly with estimation of the model for the gaps. This option is left as a suggestion for future research.

Another way to improve the theoretical model and the empirical model is to replace net lending by taxes and expenditures. This will increase the computational burden, but it would potentially be valuable since it would provide policymakers different fiscal multipliers for taxes and expenditures, which is important for the choice of effective stabilization measures. Another question concerns fiscal policy measures that are considered to be most effective in cases where the interest rate is constrained by the effective lower bound.[10]

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[10]Farhi et al. (2013); Correia (2016) is a good starting point for such an investigation.

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A The theoretical model

The empirical model used in this paper to estimate the link between monetary and fiscal policy is a structural VAR model (see the description of the empirical model in Appendix C). It is structural in the sense that assumptions need to be made concerning how shocks of different variables affect all variables in the VAR system contemporaneously (i.e. in the same period). The structure can be based on either previous empirical findings or theoretically derived relationships between variables using a macroeconomic model. In this paper, we have chosen the latter approach. This semi-structural approach is based on a 3-equation structural macro model: An IS curve, a Phillips curve and an interest rate-based monetary policy rule (commonly referred to as a Taylor rule).[11] These three equations are completed with fiscal policy and extended with a budgetary policy rule for the government. To derive this semi-structural model, we begin with a few definitions and assumptions. Disposable income in next period (YD_{t+1}) is defined as income (Y_{t+1}) plus the interest received from government bonds ($r^{PD}_{t+1}PD_t$ where PD_t is the public sector's gross debt and r^{PD}_{t+1} is the interest rate on government bonds) minus the tax payment (T_{t+1}),

$$YD_{t+1} = Y_{t+1} - T_{t+1} + r^{PD}_{t+1}PD_t. \tag{A1}$$

In a macroeconomic context, it is simply assumed that the government taxes all incomes at the rate τ and at the same time hands out a lump sum transfer tr to the households. This means that $T = \tau Y - tr$. In reality, there are of course many different taxes (such as income taxes, VAT, sales taxes, and social security contributions) and transfers. The disposable income is divided into private consumption (C_{t+1}) and the private sector's financial savings or net lending (B^{HF}_{t+1}), which is the total savings in the economy (B_{t+1}) minus the government's financial savings or net lending (B^{P}_{t+1}),

$$YD_{t+1} = C_{t+1} + B^{HF}_{t+1} = C_{t+1} + B_{t+1} - B^{P}_{t+1}. \tag{A2}$$

The total savings in an economy can be either invested in real capital (I_{t+1}) or invested abroad (which is the current account according to national accounts, that is the difference between exports and imports, $NX_{t+1} = X_{t+1} - M_{t+1}$),

$$B_{t+1} = I_{t+1} + NX_{t+1}. \tag{A3}$$

Moreover, we also define the general government's budget balance or net lending (B^{P}_{t})

$$B^{P}_{t+1} = T_{t+1} - G_{t+1} - r^{PD}_{t+1}PD_t, \tag{A4}$$

where $PB^{P}_{t+1} = T_{t+1} - G_{t+1}$, is the primary balance and G is the sum of government consumption and investment. The general government's budget balance has a

[11] See e.g. Yoshino et al. (2017).

negative impact on the government's budget constraint

$$PD_{t+1} = PD_t - B^P_{t+1} = PD_t + r^{PD}_{t+1} PD_t - (T_{t+1} - G_{t+1}). \tag{A5}$$

Using (A1)–(A4), we get the known definition for real GDP (Y) as

$$Y_{t+1} = C_{t+1} + I_{t+1} + G_{t+1} + NX_{t+1}. \tag{A6}$$

In the national accounts system, the equality in (A6) holds in nominal values. In this appendix, we use real quantities Y, C, and so on to develop the theories behind the estimated models. The quantities must be multiplied by prices for the equation to hold. Here we have assumed that all prices are equal to unity. It is important to distinguish between output and GDP. Output in the national accounts system is the value of production which measures the sales of all firms and the value of production in the public sector. This measure is not a good measure of goods that can be used for consumption and investment because a large amount of output is used as input in other firms, so-called intermediate goods. If the value of intermediate goods is subtracted from the value of output, we get value added. GDP is the sum of all value added produced in the economy.

If we divide the left and the right side of Equation (A5) by nominal GDP in period t (Y^N_t) and assuming that the nominal GDP increases with g_t, we can rewrite Equation (A5) as follows

$$pd_{t+1} = \left(\frac{1}{1+g_{t+1}}\right) pd_t - b^P_{t+1}, \tag{A7}$$

where $pd_{t+1} = PD_{t+1}/Y^N_{t+1}$ is the public sector's gross debt ratio in period $t+1$, $Y^N_{t+1} = (1+g_{t+1})Y^N_t$, and $b^P_{t+1} = B^P_{t+1}/Y^N_{t+1}$ is the net lending as a share of GDP.

The IS curve To derive the IS curve, private consumption in each period is assumed to be a constant elasticity function of different components of real disposable income (YD_t) and real interest rate (r_t), $C_{t+1} = \alpha^C_{o,t} r_t^{-\alpha^C_{1,t}} YD_t^{\alpha^C_{2,t}}$. Private investment in each period is at the same time assumed to be a constant elasticity function of the real interest rate, $I_{t+1} = \alpha^I_{o,t} r_t^{-\alpha^I_{1,t}}$. Net exports in each period are at the same time assumed to be a constant elasticity function of different components of the real disposable income, the real interest rate, foreign GDP (Y^F_t), and the real exchange rate (e^r_t), $NX_{t+1} = \alpha^{NX}_{o,t} r_t^{-\alpha^{NX}_{1,t}} (e^r_t)^{-\alpha^{NX}_{2,t}} (Y^F_t)^{\alpha^{NX}_{3,t}} (YD_t)^{\alpha^{NX}_{4,t}}$. Below we make a linear approximation of (A6) using a first-order Taylor expansion. If f is a function, then we can approximate $f(x)$ about the point where $x = a$ by the polynomial $f(x) \approx f(a) + f'(a)(x - a)$, which is a first-order Taylor series approximation of f about a. The approximation gives us the following expression for the GDP gap:

$$\begin{aligned} Y_{t+1} - Y_{t+1}^e = & -Y'_{r,t}(r_t - r_t^e) + Y'_{r,t}(Y_t - Y_t^e) - Y'_{T,t}(T_t - T_t^e) \\ & + Y'_{r_t^{PD}PD_{t-1},t}[r_t^{PD}PD_{t-1} - (r_t^{PD}PD_{t-1})^e] \\ & + Y'_{Y^F,t}\left(\frac{Y_t^F - Y_t^{Fe}}{Y_t^{Fe}}\right) - Y'_{e^r}\left(\frac{e_t^r - e_t^{re}}{e_t^{re}}\right) + Y'_{G,t}(G_{t+1} - G_{t+1}^e), \end{aligned} \tag{A8}$$

where Y', the partial derivative of GDP with respect to either r, Y, T, Y^F, e^r, G or $r^{PD}PD$, is evaluated at its equilibrium value, and the superscript "^{e}" denotes trends (or equilibriums). Extending the right-hand side of (A8) with $(G_t - G_t^e - G_t + G_t^e)$ and using (A4), we can rewrite (A8) as follows

$$\begin{aligned} Y_{t+1} - Y_{t+1}^e = & -Y'_{r,t}(r_t - r_t^e) - Y'_{T,t}(B_t^P - B_t^{Pe}) + Y'_{Y^F,t}\left(\frac{Y_t^F - Y_t^{Fe}}{Y_t^{Fe}}\right) - Y'_{e^r}\left(\frac{e_t^r - e_t^{re}}{e_t^{re}}\right) \\ & + (G_{t+1} - G_{t+1}^e) - Y'_{T,t}(G_t - G_t^e) + Y'_{Y,t}(Y_t - Y_t^e) \end{aligned} \tag{A9}$$

where $B_t^P = T_t - G_t - r_t^{PD}PD_{t-1}$ and $B^{Pe} = T_t^e - G_t^e - r_t^{PD}PD_{t-1}$. Let us now assume that government taxes in each period are a constant elasticity function of GDP, $T_t = \alpha_{o,t}^T Y_t^{\alpha_{1,t}^T}$. Moreover, we assume that government consumption in each period is a constant elasticity function of unemployment (U), $G_t = \alpha_{o,t}^G U_t^{\alpha_{1,t}^G}$. Unemployment itself is assumed to be a constant elasticity function of GDP (that is Okun's rule), $U_t = \alpha_{o,t}^U Y_t^{-\alpha_{1,t}^U}$. Including Okun's rule into the government consumption function, we can rewrite the equation for government consumption as $G_t = \alpha_{o,t}^G (\alpha_{o,t}^U)^{\alpha_{1,t}^G} Y_t^{-\alpha_{1,t}^U \alpha_{1,t}^G}$. A first-order Taylor expansion of government taxes and consumption gives us the following expressions for government consumption and taxes in gap form, $T_t - T_t^e = T'_{Y,t}(Y_t - Y_t^e)$ and $G_t - G_t^e = -G'_{Y,t}(Y_t - Y_t^e)$ where T' and G', which are the partial derivatives of T and G with respect to Y, are evaluated in equilibrium. Using $G_t - G_t^e = -G'_{Y,t}(Y_t - Y_t^e)$, we can rewrite the IS equation in (A9),

$$\begin{aligned} Y_{t+1} - Y_{t+1}^e = \frac{1}{1 + G'_{Y,t}} \Bigg[& - Y'_{r,t}(r_t - r_t^e) - Y'_{T,t}(B_t^P - B_t^{Pe}) + Y'_{Y^F,t}\left(\frac{Y_t^F - Y_t^{Fe}}{Y_t^{Fe}}\right) \\ & - Y'_{e^r,t}\left(\frac{e_t^r - e_t^{re}}{e_t^{re}}\right) + Y'_{T,t}(1 + G'_{Y,t})(Y_t - Y_t^e)\Bigg]. \end{aligned} \tag{A10}$$

The output gap is often measured as the difference between actual output and potential output as a share of potential output. To write the final expression more succinctly, we let bars denote gaps, so that $\bar{r}_t = r_t - r_t^e$, $\bar{b}_t = \frac{B_t^P - B_t^{Pe}}{Y_t^e}$, $\bar{e}_t = \frac{e_t^r - e_t^{re}}{e_t^{re}}$, $\bar{y}_t = \frac{Y_t - Y_t^e}{Y_t^e}$ and $\bar{y}_t^F = \frac{Y_t^F - Y_t^{Fe}}{Y_t^{Fe}}$. We then obtain:

$$\bar{y}_{t+1} = -\alpha_{1,t}^Y \bar{r}_t - \alpha_{2,t}^Y \bar{b}_t + \alpha_{3,t}^Y \bar{y}_t^F - \alpha_{4,t}^Y \bar{e}_t + \alpha_{5,t}^Y \bar{y}_t \tag{A11}$$

where $\alpha_{1,t}^Y = \frac{Y'_{r,t}}{Y_t^e(1+G'_{Y,t})}$, $\alpha_{2,t}^Y = \frac{Y'_{T,t}}{1+G'_{Y,t}}$, $\alpha_{3,t}^Y = \frac{Y'_{Y^F,t}}{Y_t^e(1+G'_{Y,t})}$, $\alpha_{4,t}^Y = \frac{Y'_{e^r,t}}{Y_t^e(1+G'_{Y,t})}$ and $\alpha_{5,t}^Y = Y'_{T,t}$. The equilibrium value of net lending, $\frac{B_t^{Pe}}{Y_t^e}$, is assumed to coincide with the surplus target b^T. The GDP gap is assumed to be a positive function of foreign GDP while it is a negative function of the real interest rate, the general government's budget balance, and the real exchange rate.

Phillips curve The Phillips curve in (A12) states that inflation has a positive relationship with the output gap

$$\pi_{t+1} = \pi_t + \gamma_t \bar{y}_{t+1}. \tag{A12}$$

Monetary policy rule A monetary policy rule is usually used to describe how the central bank should change interest rates. To derive a monetary policy rule, the central bank is assumed to minimize a loss function, where the central bank is assumed to keep inflation (π) in next period $t+1$ close to the target whilst avoiding large output fluctuations,

$$L = \beta_{Y,t}^M \bar{y}_{t+1}^2 + \beta_{\pi,t}^M \bar{\pi}_{t+1}^2, \tag{A13}$$

where $\bar{\pi}_t = \pi_t - \pi^T$ and π^T is the inflation target. Any deviation in output from equilibrium or inflation from the target, in either direction, produces a loss in utility for the central bank. The critical parameter in the central bank's loss function is $\beta_{\pi,t}^M$. $\beta_{\pi,t}^M > \beta_{Y,t}^M$ will characterize a central bank that places less weight on output fluctuations than on deviations in inflation. The central bank optimizes its decision by minimizing its loss function (A13) subject to the Phillips curve (A12). By substituting the Phillips curve equation into the loss function and differentiating with respect to Y_{t+1}, we get the monetary policy rule

$$\bar{\pi}_t = -\left(\gamma_t + \frac{\beta_{\gamma,t}^M}{\beta_{\pi,t}^M \gamma_t}\right) \bar{y}_{t+1}. \tag{A14}$$

Substituting the output gap (A11) into (A14), we get the interest rate-based monetary policy rule

$$\bar{r}_t = \alpha^r_{1,t}\bar{\pi}_t - \alpha^r_{2,t}\bar{b}_t + \alpha^r_{3,t}\bar{y}^F_t - \alpha^r_{4,t}\bar{e}_t + \alpha^r_{5,t}\bar{y}_t, \tag{A15}$$

where $\alpha^r_{1,t} = \frac{1}{\left[\gamma_t + \frac{\beta^M_{y,t}}{\beta^M_{\pi,t}\gamma_t}\right]\alpha^Y_{1,t}}$, $\alpha^r_{2,t} = \frac{\alpha^Y_{2,t}}{\alpha^Y_{1,t}}$, $\alpha^r_{3,t} = \frac{\alpha^Y_{3,t}}{\alpha^Y_{1,t}}$, $\alpha^r_{4,t} = \frac{\alpha^Y_{4,t}}{\alpha^Y_{1,t}}$, and $\alpha^r_{5,t} = \frac{\alpha^Y_{5,t}}{\alpha^Y_{1,t}}$. According to this rule, the policy rate varies around a long-run real interest rate level where its variations depend on how inflation relates to the inflation target, how resource utilization relates to its long-run level, how foreign resource utilization relates to its long-run level, how real exchange rate relates to its long-run level, and how the general government's net lending relates to surplus target. The parameters in front of the different gaps state by how much the policy rate reacts to deviations of different variables from their long-run levels.

Budgetary policy rule To derive the budgetary rule, we divide the government's net lending by potential GDP. This yields

$$b^P_t = t_t - g_t - r^{PD}_t pd_{t-1}. \tag{A16}$$

The government's net lending can be decomposed into structural components (b^{PS}_t) and cyclical components (b^{PC}_t)

$$b^P_t = b^{PS}_t + b^{PC}_t. \tag{A17}$$

The cyclical component is assumed to represent the effect on net lending from the automatic stabilizers. Actual net lending is observable — it can be read off directly and does not have to be estimated statistically — whereas both the cyclical and the structural component must be estimated. The first step in the usual approach involves estimating the government finances' sensitivity to fluctuations in the business cycle which we formulated earlier as follows: $T_t - T^e = T'_{Y,t}(Y_t - Y^e)$ and $G_t - G^e = -G'_{Y,t}(Y_t - Y^e)$. By using these equations, we can derive following cyclical component of net lending

$$b^{PC}_t = (T'_{Y,t} - G'_{Y,t})\bar{y}_t. \tag{A18}$$

By substituting (A18) into (A17), we can rewrite the expression for the government's net lending as

$$b_t^P = b_t^{PS} + (T'_{Y,t} - G'_{Y,t})\bar{y}_t. \tag{A19}$$

The budget elasticity $\theta_t = (T'_{Y,t} - G'_{Y,t})$ indicates the extent to which a change in the output gap affects net lending. The budget elasticity is therefore assumed to catch the aggregated impact of the automatic stabilizers. Using the estimated equation, the structural balance can be calculated as[12]

$$b_t^{PS} = b_t^P - \theta_t \bar{y}_t. \tag{A20}$$

The government is assumed to minimize a loss function, where the government is assumed to keep structural balance close to the targeted surplus for the general government net lending whilst avoiding large demand and supply disturbances. The loss function

$$L = j_Y \beta^F_{Y,t} \bar{y}_t^2 + j_\pi \beta^F_{\pi,t} \bar{\pi}_t^2 + \beta^F_{B,t} \bar{b}_t^2, \tag{A21}$$

where $\beta^F_{Y,t}$ is the weight that the government puts on stabilizing the output, $\beta^F_{\pi,t}$ is the weight that the government put on stabilizing inflation, and $\beta^F_{B,t}$ is the weight that the government puts on the surplus target. The parameter j_Y is used to capture large demand disturbances while j_π is used to capture large supply disturbances. Large demand disturbances are defined as situations where the GDP gap is lower than certain levels (ω_Y) so that $j_Y = 1$ if $-\omega_Y < \bar{Y}_{t+1} < \omega_Y$ and 0 otherwise. In the Swedish Government letter 2017/18: 207 "Framework for fiscal policy", a normal economic situation is defined as a GDP gap between 1.5 and -1.5 per cent of potential GDP. Large supply disturbances are defined as situations where the inflation gap is lower than certain levels (ω_π) so that $j_\pi = 1$ if $-\omega_\pi \leq \bar{\pi}_t \leq \omega_\pi$ and 0 otherwise. The government optimizes by minimizing its loss function (A21) subject to the structural balance (A20) and the Phillips curve (A14). By substituting (A14) and (A20) into the loss function and differentiating with respect to Y_t, we get the following budgetary

[12] The interested reader is referred to Boije (2004) for a detailed description of different methods for calculating the general government structural budget balance.

policy rule:

$$\bar{b}_t = \theta_t \bar{y}_t + \left(\frac{j_Y \beta^F_{Y,t}}{\theta_t \beta^F_{B,t}} \right) \bar{y}_t + \left(\frac{j_\pi \beta^F_{\pi,t}}{\theta_t \beta^F_{B,t}} \right) \gamma_t \bar{\pi}_t. \tag{A22}$$

In optimum, actual net lending varies around the surplus target to "automatically" return to the balance level when the GDP gap is closed in the current and previous period and the inflation gap is closed. As noticed in (A20), $\theta_t \bar{y}_t$ is the aggregated impact of the automatic stabilizers. The next term in (A22), $\left(\frac{j_Y \beta^F_{Y,t}}{\theta_t \beta^F_{B,t}} \right) \bar{y}_t$, captures the government's discretionary stabilization policy in case of large demand disturbances. An interesting observation is that the discretionary stabilization policy in this case is a function of the weight on output fluctuations and the surplus target, the budget elasticity, and how sensitive inflation is to output fluctuations. This means that if the impact of automatic stabilizers increases, then the government's need to undertake discretionary fiscal stabilization policy diminishes. At the same time, if a government attaches great importance to meeting the surplus target, it means that they will put less emphasis on stabilizing output. The last term in (A22) captures the government's discretionary stabilization policy in case of large supply disturbances. Interestingly, discretionary stabilization policy is in this case a function of the weight on the inflation gap and the surplus target, the budget elasticity, and how sensitive inflation is to output fluctuations. We finish by rewriting (A22) as follows

$$\bar{b}_t = \alpha^B_{1,t} \bar{y}_t + \alpha^B_{2,t} \bar{\pi}_t, \tag{A23}$$

where $\alpha^B_{1,t} = \theta_t + \left(\frac{j_Y \beta^F_{Y,t}}{\theta_t \beta^F_{B,t}} \right)$ and $\alpha^B_{2,t} = \left(\frac{j_\pi \beta^F_{\pi,t}}{\theta_t \beta^F_{B,t}} \right) \gamma_t$ and by summarizing below the most important theoretical equations that we use as starting point to formulate the empirical model:

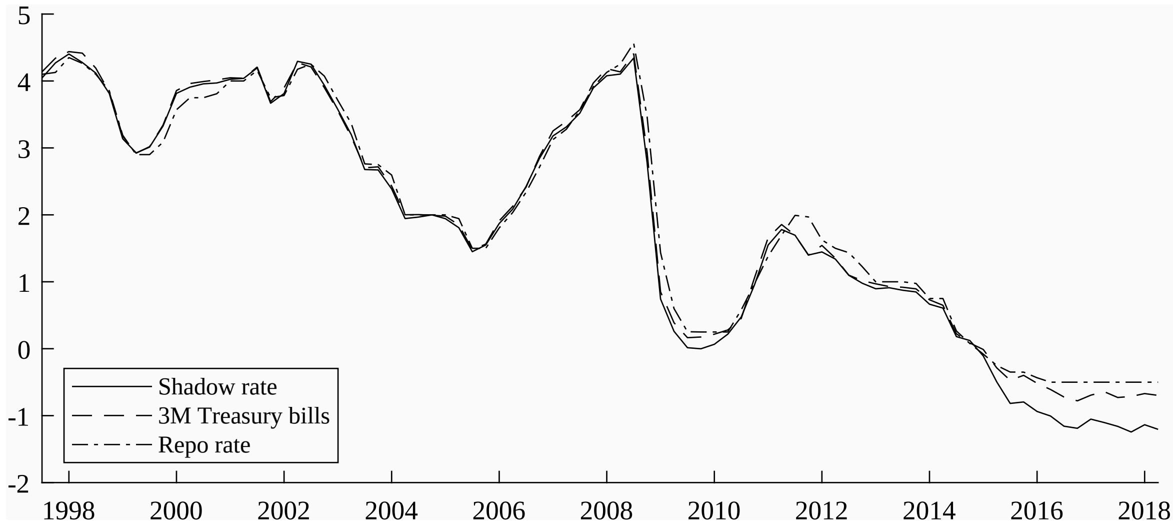
$$\begin{aligned}
\bar{b}_t &= \alpha^B_{1,t} \bar{y}_t + \alpha^B_{2,t} \bar{\pi}_t && \text{(Budgetary policy rule)} \\
\bar{r}_t &= \alpha^r_{1,t} \bar{\pi}_t - \alpha^r_{2,t} \bar{b}_t + \alpha^r_{3,t} \bar{y}^F_t - \alpha^r_{4,t} \bar{e}_t + \alpha^r_{5,t} \bar{y}_t && \text{(Monetary policy rule)} \\
\bar{\pi}_t &= \bar{\pi}_{t-1} + \alpha^\pi_{2,t} \bar{y}_t && \text{(Phillips curve)} \\
\bar{y}_{t+1} &= -\alpha^Y_{1,t} \bar{r}_t - \alpha^Y_{2,t} \bar{b}_t + \alpha^Y_{3,t} \bar{y}^F_t - \alpha^Y_{4,t} \bar{e}_t + \alpha^Y_{5,t} \bar{y}_t. && \text{(Output gap)}
\end{aligned}$$

B Data

According to the theoretical model in Appendix A, the following variables should be included in the empirical model: real interest gap, GDP gap, foreign GDP gap, inflation gap, net lending gap, and real exchange rate gap. The variables used are summarized in Table 4 and illustrated in Figure 4.

Real interest gap The sample that we use to estimate our empirical model includes the period of effective lower bound (ELB) in which the Riksbank lowered its key rate to -0.5 per cent and began to use unconventional measures, such as buying Swedish government bonds with longer maturities. If we fail to control for the fact that unconventional monetary policy was conducted from 2015 in order to boost the economy, then there is a risk that this will be interpreted as a consequence of other shocks such as fiscal policy shocks. To control for both conventional and non-conventional monetary policy, we follow the recommendation by Klein and Linnemann (2018) and replace the interest rate on three months treasury bills with the shadow rate in the empirical model.[13] Before 2015, the shadow rate equalled the repo rate because the ELB was not binding. After 2015, the two rates differ because of the unconventional monetary policy (Figure 3) that was conducted. It is worth mentioning that the interest rate on three months treasury bills is also affected by both conventional and unconventional monetary policy. However, it does not include the impact that unconventional monetary has on the entire yield curve, which is the case for the shadow rate. As is evident, the correlations between the repo rate, the interest rate on three months treasury bills and the shadow rate are very high. We use the shadow rate to generate the real interest rate (r_t). We define the real interest rate as the shadow rate (i_t) minus expected inflation one year ahead $(\pi^e_{t+4}), r_t = i_t - \pi^e_{t+4}$. As suggested by Laubach and Williams (2003), inflation expectations are proxied by the prediction for the four-quarter-ahead percentage change in inflation, $\pi^e_{t+4} = \hat{\pi}_{t+4|t}$, where $\hat{\pi}_{t+4|t}$ is the forecast from a univariate AR(3) process with a rolling estimation window of 40 quarters. Finally, we define the real interest gap as the real interest rate minus the trend of the same variable (r^e_t), $r_t = r_t - r^e_t$. The trend is calculated using a one-sided Hodrick-Prescott filter (HP filter) with smoothing parameter equal to 1600. Because the shadow rate is so highly correlated with the short-term interest rate, the results presented in the main text are invariant to the specific choice of interest rate series.

[13]The shadow rate we use was kindly provided to us by De Rezende and Ristiniemi (2018). See also Wu and Xia (2016).



Sources: Data provided by De Rezende and Ristiniemi (2018).

Figure 3: Shadow rate estimates for Sweden, Per cent

Real GDP gap We use quarterly data on the real seasonally adjusted GDP gap (y_t) provided by the National Institute of Economic Research (NIER).

Foreign real GDP gap We define real GDP gap in the rest of the world as KIX-weighted foreign real GDP (provided by NIER) minus the trend of the same variable (Y_t^{Fe}) divided by the trend, $\bar{y}_t^F = \frac{Y_t^F - Y_t^{Fe}}{Y_t^{Fe}}$. KIX, which is an index based on exchange rates weighted based on 32 countries significance for Swedish foreign trade, can be downloaded from either the Riksbank's or the NIER's websites. The trend is calculated using a one-sided HP filter with smoothing parameter equal to 1600.

Inflation gap Core inflation is measured as the year-on-year percentage change of seasonally adjusted CPIF, the consumer price index with a fixed interest rate. CPIF is the measure that the Riksbank is officially targeting since September 2017. The inflation gap is defined as core inflation minus the inflation target, which in Sweden is 2 per cent, $\bar{\pi}_t = \pi_t - \pi^T$.

Real exchange rate gap The effective real exchange rate used to generate the effective real exchange gap is the index KIX (an increase implies a depreciation of the krona, and a decrease implies an appreciation). We define the real exchange rate gap ($\bar{e}_t$) as the real exchange rate minus the trend of the same variable (e_t^{re}), $\bar{e}_t = \frac{e_t^r - e_t^{re}}{e_t^{re}}$. The trend is calculated using one-sided HP-filter with smoothing parameter equal to

1600.

Net lending gap The public sector's net lending gap is calculated using quarterly nominal net lending from Statistics Sweden and potential GDP from NIER. We define the net lending gap as the ratio between net lending and potential GDP minus the surplus target, which in Sweden was 1 per cent during the studied period, $\bar{b}_t = (B_t^P - B_t^{Pe})/Y_t^e$.

The extended structural macro model in Appendix A is a simple macro model that only includes the main transmission mechanism of fiscal policy. However, there are a few other transmission channels that we need to control for in order to be able to draw adequate conclusions regarding the interaction between fiscal and monetary policies. In what follows we will describe variables that we use to control for the self-financing channel of government spending, for the financial accelerator mechanism of fiscal policy, the confidence channel of fiscal policy and fiscal foresight channel.

Debt ratio gap According to *the self-financing channel of government spending*, higher government spending may reduce the public debt burden by decreasing the debt-to-GDP ratio. Auerbach and Gorodnichenko (2012) argue that government spending may even be self-financed because it can boost the economy during recessions. To control for this, we use the ratio of government debt over GDP to generate the debt ratio gap ($\bar{d}_t$), which is calculated by dividing the public sector's gross debt by nominal GDP. We define debt ratio-gap as the debt ratio minus the trend of the same variable (D_t^e), $\bar{d}_t = D_t - D_t^e$. The trend is calculated using a one-sided HP-filter with smoothing parameter equal to 1600.

Debt ratio gap controls to some extent for the fiscal theory of pricing mechanism, explained in a simple way in Leeper (2016). The basic idea behind this mechanism is that in nominal terms, government must pay off its existing liabilities (government debt) either by refinancing (rolling over the debt, issuing new debt to pay the old) or amortizing (paying it off from budget surpluses). In real terms, a government can also inflate away the debt: if it causes or allows high inflation, the real amount it must repay will be smaller. The fiscal theory of pricing states that if a government has an unsustainable fiscal policy, such that it will not be able to pay off its obligation in future out of budget surpluses (it runs a persistent structural deficit), then it will pay them off via inflating the debt away.

Spread gap According to *the financial accelerator mechanism of fiscal policy*, a worsening of the public sector's net lending — meaning a fiscal expansion — is expected to reduce the financing costs of firms (see e.g. Canzoneri et al., 2016). If this is the case then a fiscal expansion should decrease the spread and affect the size of the fiscal multiplier. To control for the financial accelerator mechanism of fiscal policy, we use the spread between the lending rate and the interest rate on 10 years government bonds (S_t) to generate the spread gap.[14] We define the spread gap as the spread minus the trend of the same variable, $\bar{s}_t = S_t - S_t^e$, where S_t^e is calculated using a one-sided HP filter with smoothing parameter equal to 1600.

Consumer confidence gap According to *the confidence channel of fiscal policy*, an expansive fiscal policy is more effective in stimulating economic activity by affecting consumer confidence (see e.g. Bachmann and Sims, 2012). An increase in confidence leads to a significant and sizeable rise in private consumption since consumers interpret fiscal expansion as policymakers' commitment to macroeconomic stabilization. However, the strength of this effect can depend on the state of the business cycle. We use an index of consumer confidence (C_t) from the NIER. It is based on a survey among a nationally representative sample of households on a variety of questions concerning personal and aggregate economic conditions. The idea behind the confidence channel is that a worsening of net lending should increase the confidence indicator and the size of the fiscal multiplier. We define consumer confidence gap as the consumer confidence index minus the trend of the same variable (C_t^e) divided by the trend, $\bar{c}_t = \frac{C_t - C_t^e}{C_t^e}$. The trend is calculated using a one-sided HP filter with smoothing parameter equal to 1600.

Expected discretionary policy gap According to *the fiscal foresight channel*, the private sector may anticipate government spending changes and change its behaviour before they are announced. To control for fiscal foresight, we use real-time forecasts for net lending made by NIER and divide it by NIER's view concerning the potential GDP (NLP_t). We filter this series, using a one-sided HP filter, to get an idea about the structural balance made by the NIER, $SNLP_t^e$. However, this structural balance does not reflect the real-time judgment of structural balance made by the NIER.

[14]Klein and Linnemann (2018) use instead the corporate-to-government bond yield spread in their empirical study for the US. In Sweden, the corporate bond market is not well developed and the liquidity at this market is very low. The reason is that Swedish corporations borrow heavily from private banks instead of issuing own bonds. The Swedish banks that lend to non-financial firms issue own bonds or equity to finance this lending.

Table 4: Variables used in the empirical model

Variable	Unit	Name	Mean	St. dev.
Foreign real GDP gap†	Per cent	$\bar{y}_t^F$	0.02	1.05
Real GDP gap†	Per cent	$\bar{y}_t$	-0.95	2.30
Inflation gap†	Percentage unit	$\bar{\pi}_t$	-0.48	0.69
Real interest gap§	Percentage unit	$\bar{r}_t$	0.00	0.77
Real exchange rate gap†	Per cent	$\bar{e}_t$	-0.04	3.21
Net lending gap†	Percentage unit	$\bar{b}_t$	0.36	1.26
Debt ratio gap†	Percentage unit	$\bar{d}_t$	0.03	2.14
Spread gap*	Percentage unit	$\bar{s}_t$	-0.03	0.58
Consumer confidence gap†	Per cent	$\bar{c}_t$	-0.77	7.32
Expected discretionary policy gap†	Percentage unit	$\bar{eb}_t$	0.06	0.67

Data sources: (∗) Macrobond and own calculations, (†) Statistics Sweden and own calculations, (‡) NIER and own calculations, (§) De Rezende and Ristiniemi (2018) and own calculations.

The reason is that we lack data concerning the NIER's real-time judgment for the period 1997–2011. To keep the data consistent, we have chosen to approximate the structural balance using the HP filter just to get an idea about the trend of real-time forecasts for net lending made by the NIER. The change of the NIER's structural balance ($\Delta_4 SNLP_t^e = SNLP_t^e - SNLP_{t-4}^e$) is considered to give an idea about the direction of the fiscal policy stance anticipated by NIER. Simply put, this is the NIER's view concerning the magnitude of the discretionary fiscal policy undertaken by the government. The anticipated discretionary policy is then used to generate the expected discretionary fiscal policy in gap terms ($\bar{eb}_t$). We define $\bar{eb}_t$ as the change of the NIER's structural balance minus the trend of the same variable ($(\Delta_4 SNLP_t^e)^e$), $\bar{eb}_t = \Delta_4 SNLP_t^e - (\Delta_4 SNLP_t^e)^e$. The trend is calculated using a one-sided HP filter with smoothing parameter equal to 1600.

C The empirical model

It is important to notice that all parameters in the theoretical equations in Appendix A are composed of different underlying parameters, which can change over time due to structural changes or changed preferences of policymakers. Another important point is that there are obvious contemporaneous as well as lagged theoretical interrelationships between different variables. The objective here is to provide a flexible framework for the estimation and interpretation of time variation in the systematic and non-systematic part of fiscal and monetary policy and their effect on the rest of the economy.

The model used is a time-varying structural Bayesian vector autoregressive model with stochastic volatility.[15] A time-varying VAR is similar to a traditional VAR, except that it admits the dynamic coefficients to become period-specific. We use two lags leading to the model

$$\mathbf{y}_t = \mathbf{A}_{1,t} y_{t-1} + \mathbf{A}_{2,t}\mathbf{y}_{t-2} + \mathbf{C}_t + \boldsymbol{\epsilon}_t \tag{C1}$$

where $\mathbf{y}_t' = (\bar{y}_t^F, \bar{y}_t, \bar{\pi}_t, \bar{r}_t, \bar{e}_t, \bar{b}_t, \bar{d}_t, \bar{s}_t, \bar{c}_t, \bar{eb}_t)$ is a 10×1 vector of endogenous variables and the vector $\mathbf{C}_t$ is a vector of time-varying intercepts. The matrix $\mathbf{A}_{i,t}$ $(i = 1, 2)$ is a 10×10 matrix of time-varying coefficients and $\boldsymbol{\epsilon}_t \sim N(0, \boldsymbol{\Sigma}_t)$ are the reduced-form errors with a time-varying variance-covariance matrix. Let $\mathbf{B}_t' = \begin{pmatrix} \mathbf{A}_{1,t}' & \mathbf{A}_{2,t}' & \mathbf{C}_t' \end{pmatrix}'$ and $\boldsymbol{\beta}_t = \text{vec}(\mathbf{B}_t)$. The law of motion for the regression parameters in the VAR follows Cogley and Sargent (2005) and Primiceri (2005) in which the parameters evolve as random walks

$$\boldsymbol{\beta}_t = \boldsymbol{\beta}_{t-1} + \boldsymbol{\vartheta}_t, \quad \boldsymbol{\vartheta}_t \sim N(0, \boldsymbol{\Omega}) \tag{C2}$$

where we let the covariance matrix $\boldsymbol{\Omega}$ be diagonal. In line with Cogley and Sargent (2005) $\boldsymbol{\Sigma}_t$ is decomposed as:

$$\boldsymbol{\Sigma}_t = \mathbf{F}\boldsymbol{\Lambda}_t\mathbf{F}' \tag{C3}$$

where $\mathbf{F}$ is a lower triangular matrix with ones on its main diagonal and $\boldsymbol{\Lambda}_t$ is a period-specific diagonal matrix with $\text{diag}(\boldsymbol{\Lambda}_t) = \begin{pmatrix} \hat{\sigma}_1 \exp(\lambda_{1,t}) & \cdots & \hat{\sigma}_{10} \exp(\lambda_{10,t}) \end{pmatrix}$. The constants $\hat{\sigma}_i$ $(i = 1, \ldots, 10)$ are known scaling factors, while $\lambda_{i,t}$ $(i = 1, \ldots, 10)$ are dynamic processes which generate the heteroskedasticity of the model. Specifically, it is assumed that the $\lambda_{i,t}$ terms are random walks:

$$\lambda_{i,t} = \lambda_{i,t-1} + \nu_{i,t}, \quad \nu_{i,t} \sim N(0, \phi_i^2). \tag{C4}$$

The model is estimated using Bayesian methods employing Markov Chain Monte Carlo using 5,000 draws for burnin and 25,000 in the main chain, of which we keep every fifth draw. For more details about the estimation procedure we refer the inter-

[15] We have used the Bayesian Estimation, Analysis and Regression (BEAR) Toolbox developed by Dieppe et al. (2018) to estimate and analyse the model.

Table 5: Identifying sign restrictions on impulse responses

Response \ Shock	$\bar{e}$	$\bar{r}$	$\bar{b}$	$\bar{\pi}$	$\bar{y}$	$\bar{y}^F$
$\bar{e}$	$+$					
$\bar{r}$	$-$	$+$	$-$	$+$	0	$+$
$\bar{b}$	0	0	$+$	$+$	$+$	0
$\bar{\pi}$	0	0	0	$+$	$+$	0
$\bar{y}$	$-^1$	$-^1$	$-^1$	0	$+$	$+^1$
$\bar{y}^F$	0	0	0	0	0	$+$
$\bar{s}$						
$\bar{c}$						
$\bar{eb}$						
$\bar{d}$						

Note: This table shows the sign restrictions on the impulse responses for each identified shock. A "+" means that the impulse response of the variable in question is restricted to be positive for the quarter of impact. Likewise, a "" indicates a negative response while a "0" indicates no response. A blank entry indicates that no restriction has been imposed. The superscript "1" means that the restriction is placed on the response at horizon 1, i.e. the period after the initial shock.

ested reader to Dieppe et al. (2018).

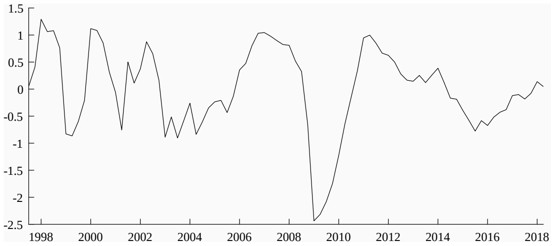
To identify shocks of interest, we use the theoretical model in Appendix A to obtain zero and sign restrictions. Sign restrictions represent the action of constraining the response of a variable to a specific structural shock to be positive or negative, whereas zero restrictions constrain the response to be exactly zero. Because sign restrictions identify only the sign of the response, exact identification cannot be achieved. Instead, only a set of models can be identified. Furthermore, we only impose restrictions on shocks that are of interest to us and for which the theory in Appendix A offers guidance. As a consequence, our identification is partial, and it identifies a set of structural models. Table 5 summarizes the partial identifying restrictions on the impact of shocks. The positive sign restrictions along the diagonal in Table 5 are for normalization purposes. For more discussion on the methodology used, see Kilian and Lütkepohl (2017).

In row 5 in Table 5, we impose sign restrictions on inflation using the Phillips curve. We allow inflation to vary contemporaneously with domestic business cycle shocks. Row 3 in Table 5 represents a monetary policy reaction function. In accordance with the theory, the Riksbank responds positively to foreign business cycle shocks, inflation shocks and negatively to fiscal policy and exchange rate shocks when setting the interest rate. However, the interest rate does not respond contemporaneously to domestic business cycle conditions. Row 4 in Table 5 represents the budget policy rule. As suggested by the theory, the government responds positively to inflation shocks and domestic business cycle shocks. However, net lending does not respond contemporaneously to foreign business cycle shocks, exchange rate shocks, and monetary policy shocks. In row 6 in Table 5, shocks of business cycle abroad in the current period has according to the theory a positive impact on the domestic business cycle in the next period. Furthermore, the theoretical model establishes that monetary policy shocks, fiscal policy shocks, and exchange rate shocks in the current period have a negative impact on the domestic business cycle in the next period. However, the domestic business cycle does not respond contemporaneously to inflation shocks. Our identification strategy largely resembles that of Gerba and Hauzenberger (2013), who similarly identify four shocks by sign restrictions and leave a fifth shock unidentified. The reason is that we are mainly interested in identifying the main transmission channel of fiscal policy while controlling for other transmission channels identified in the literature, while not necessarily identifying shocks to these control variables.

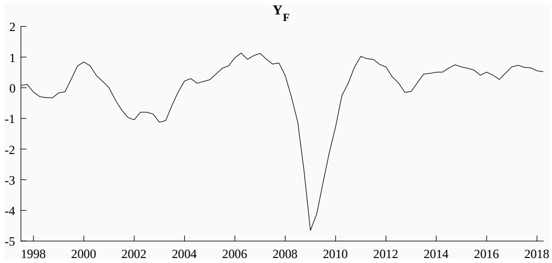
D Alternative model specification: constant BVAR

In this section, we investigate whether a standard BVAR with constant parameters and a time-invariant covariance matrix supports the findings by the time-varying parameter BVAR with stochastic volatility. The constant BVAR uses a normal-diffuse Minnesota prior with standard choices of the hyperparameters: the overall tightness is set to 0.2, the cross-variable tightness is 0.5 and the lag decay is 1. For more discussion of the normal-diffuse prior, see Karlsson (2013). The budget elasticity and the fiscal multiplier are presented in Figures 5i–5ii.

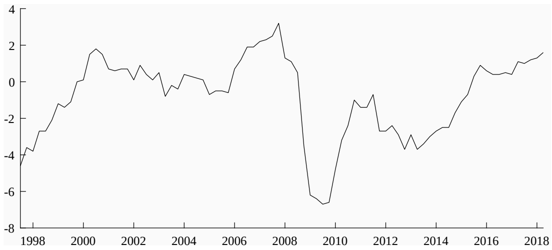
Overall, the constant BVAR paints a similar picture as the time-varying model with stochastic volatility presented in the main text. The constant BVAR estimates the budget elasticity to be somewhat lower, ranging between 0.25–0.4. The estimated fiscal multiplier is essentially the same in the two models. Thus, by and large, the constant BVAR supports the conclusions from the model with time variation and whether or not time-varying parameters and stochastic volatility is allowed is immaterial for the results.



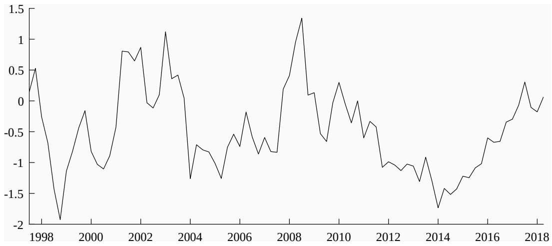
(i) Real interest rate gap ($\bar{r}_t$)



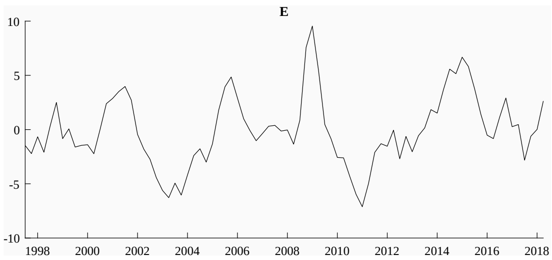
(ii) Foreign real GDP gap ($\bar{y}_t^F$)



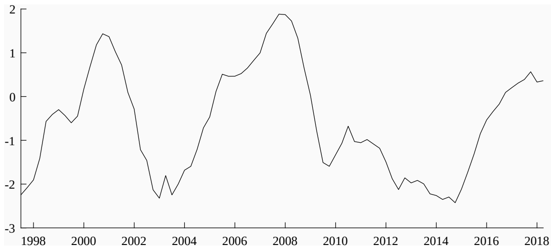
(iii) Real GDP gap ($\bar{y}_t$)



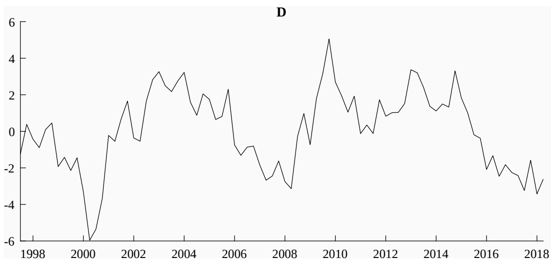
(iv) Inflation gap ($\bar{\pi}_t^F$)



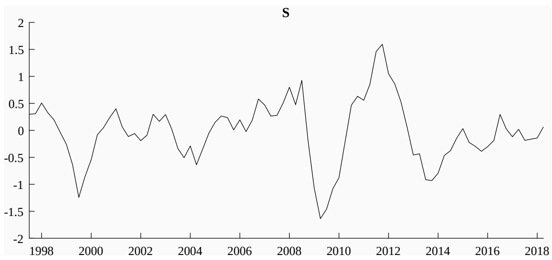
(v) Real exchange rate gap ($\bar{e}_t$)



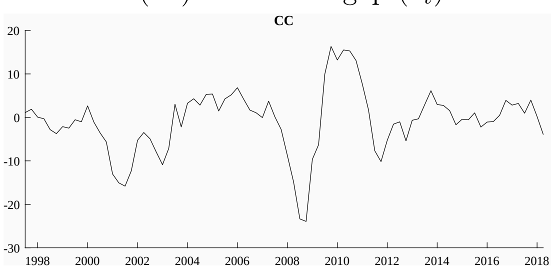
(vi) Net lending gap ($\bar{b}_t$)



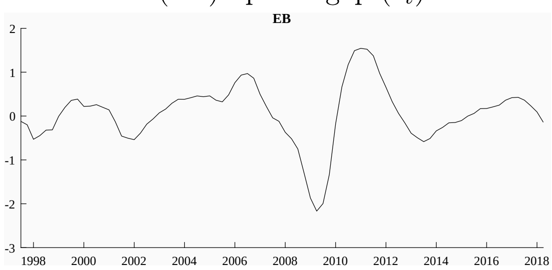
(vii) Debt ratio gap ($\bar{d}_t$)



(viii) Spread gap ($\bar{s}_t$)

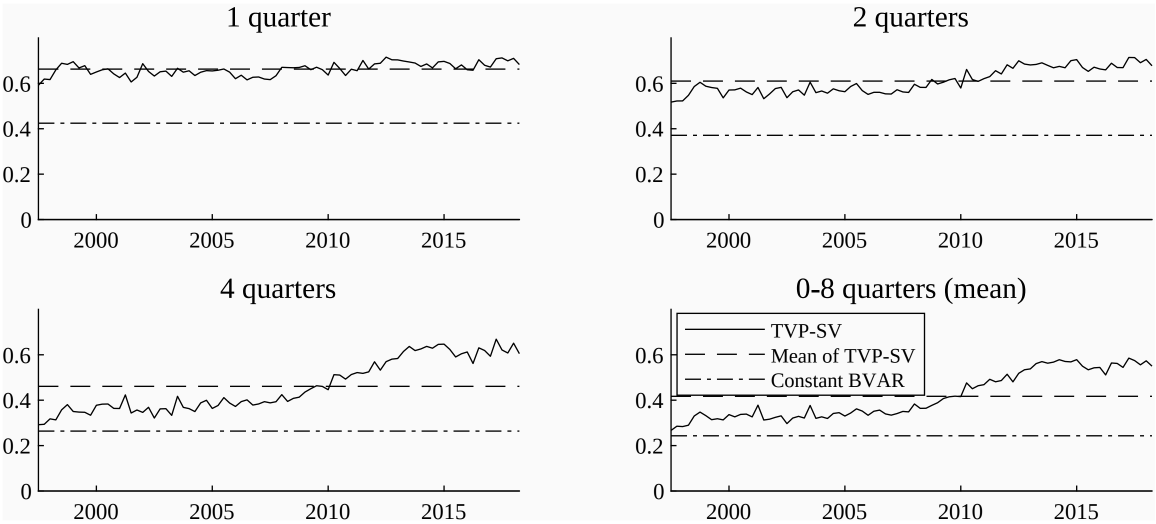


(ix) Consumer confidence gap ($\bar{c}_t$)

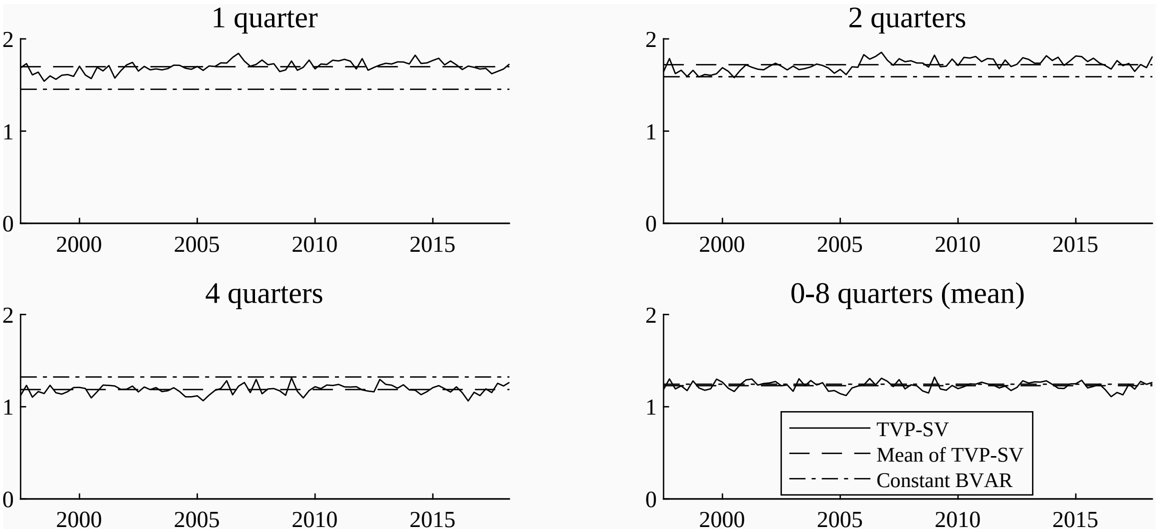


(x) Expected discretionary policy gap ($\bar{eb}_t$)

Figure 4: Data series



(i) The budget elasticity

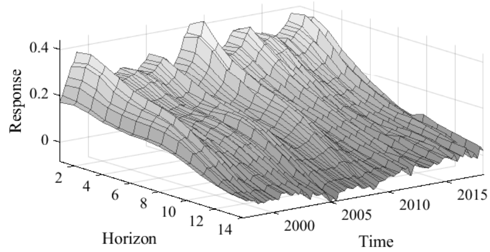


(ii) The fiscal multiplier

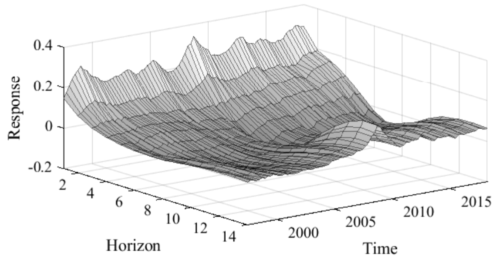
Sources: Authors' calculations.

Figure 5: Budget elasticity and fiscal multiplier in alternative model

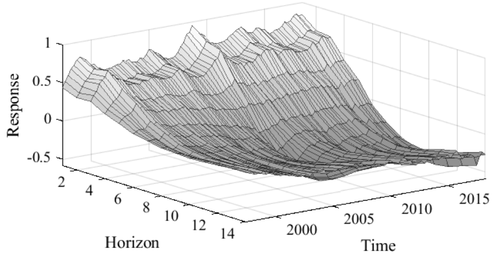
E Impulse response figures



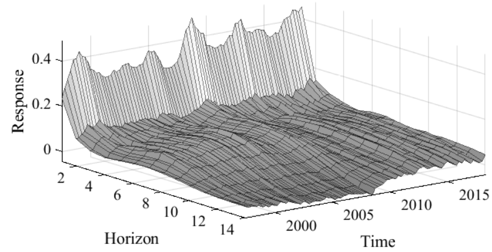
(i) Net lending ⟶ Net lending



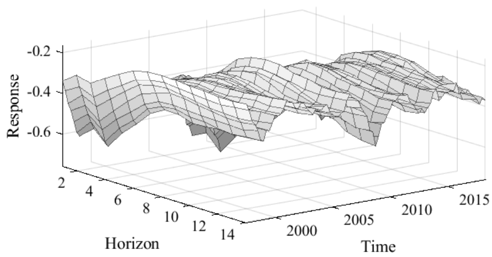
(ii) Shadow rate ⟶ Shadow rate



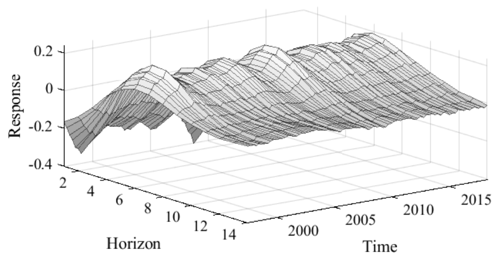
(iii) GDP ⟶ GDP



(iv) Inflation ⟶ Inflation

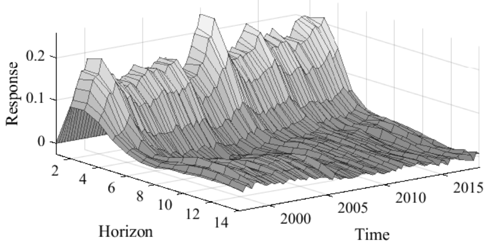


(v) Net lending ⟶ GDP

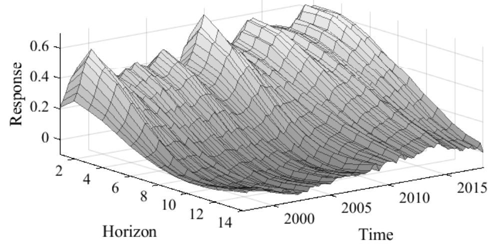


(vi) Net lending ⟶ Shadow rate

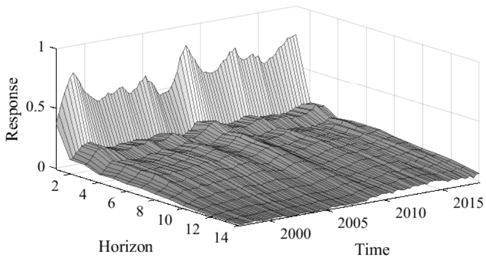
Figure 6: Impulse responses (shock ⟶ response)



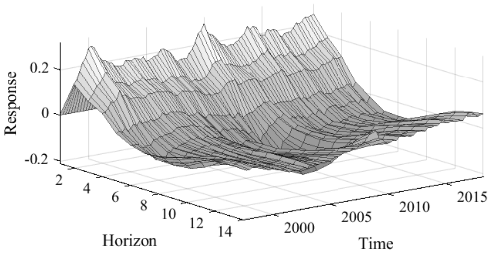
(vii) Net lending ⟶ Inflation



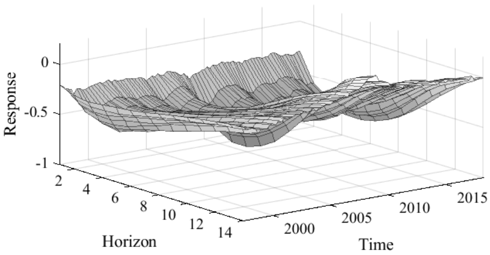
(viii) GDP ⟶ Net lending



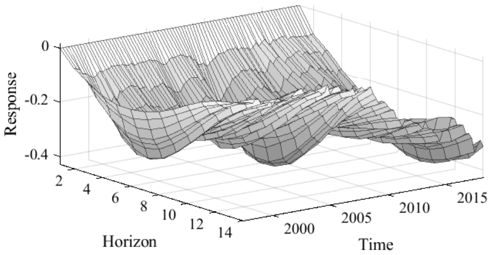
(ix) GDP ⟶ Inflation



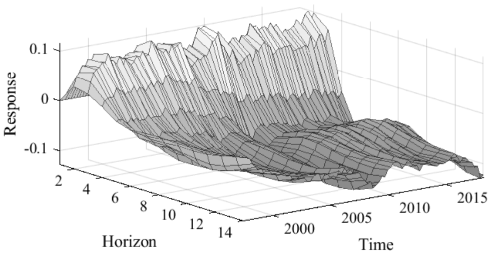
(x) GDP ⟶ Shadow rate



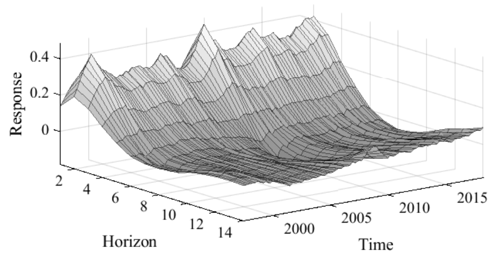
(xi) Shadow rate ⟶ GDP



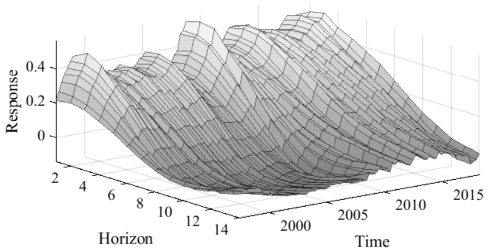
(xii) Shadow rate ⟶ Net lending



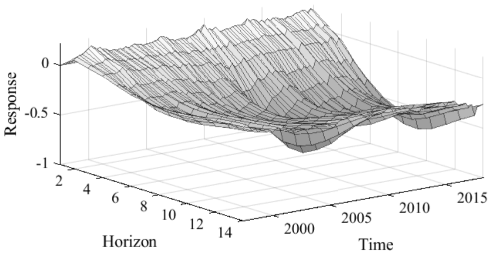
(xiii) Shadow rate ⟶ Inflation



(xiv) Inflation ⟶ Shadow rate



(xv) Inflation ⟶ Net lending



(xvi) Inflation ⟶ GDP

Figure 6: (cont.) Impulse responses (shock ⟶ response)

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