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The impact of fiscal policy on economic activity over the business cycle – evidence from a threshold VAR analysis

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Abstract:

Does the state of the business cycle matter for the effects of fiscal policy shocks on GDP? This study analyses quarterly German data from 1976 to 2009 in a threshold SVAR, expanding the SVAR approach by Blanchard and Perotti (2002). In a linear benchmark SVAR, the analysis finds that hiking spending yields a short-term fiscal multiplier of around 0.70, while the fiscal multiplier resulting from an increase in taxes and social security contributions is -0.66. In addition, the threshold model derives fundamentally new insights on the effects of shocks, depending on when in the business cycle they occur, their size and their direction. Most importantly, fiscal spending multipliers are much larger in times of a negative output gap but have only a very limited effect in times of a positive output gap. Discretionary revenue policies, on the other hand, have a generally more limited impact. Our findings have important implications for the optimal fiscal policy mix over different stages of the business cycle. Various robustness checks, including a different threshold specification, do not influence these implications substantially.

Keywords: fiscal policy, business cycle, nonlinear analysis, fiscal multipliers
JEL-Classification: E62, E32, C54.

Non-technical summary

What are the effects of fiscal policy on economic growth? How effective is it in smoothing the business cycle? Does the state of the business cycle matter for the effects of fiscal policy shocks on GDP? These policy-relevant macroeconomic questions are highly controversial, and the optimal fiscal policy action with respect to the size, timing and the policy mix is the topic of fierce debate in the literature.

This paper seeks to contribute to the empirical literature on fiscal policy in Germany by adding an additional dimension to the usual linear analysis: allowing for asymmetries of fiscal policy shocks on growth depending on their size, their direction and their timing with respect to the business cycle. We apply a threshold VAR approach, which is characterised by a separation of the observations into different regimes based on a threshold variable, to model time series non-linearities. Within each regime, the time series is then assumed to be described by a linear model. In the baseline specification, we use the output gap as the threshold variable as it divides economic development in phases of under- and overutilisation – the two regimes under which we expect the effects of fiscal stimuli to differ. To identify discretionary fiscal policy shocks, we employ exogenously determined elasticities for the working of automatic stabilisers.

Our research shows that short-term fiscal multipliers in Germany are in general moderate and that the state of the business cycle strongly matters for the effects of fiscal policy shocks. In a linear benchmark model, the analysis finds that the effect of reductions in tax and social security contributions and of increased spending on GDP each corresponds to a short-term fiscal multiplier of around 0.7, putting it in the range of other empirical results for Germany. In addition the threshold model derives fundamentally new insights on the effects of shocks, depending on their timing with respect to the business cycle. Most importantly, fiscal spending multipliers are much larger in times of a negative output gap but have only a very limited effect in times of a positive output gap. Discretionary revenue policies, on the other hand, have generally a more limited effect. With respect to the cycle, their impact is larger in the upper than in the lower output gap regime. Various robustness checks, including a different threshold specification, do not influence the resulting policy implications substantially.

Nichttechnische Zusammenfassung

Wie beeinflusst die Fiskalpolitik das Wirtschaftswachstum? Wie effektiv ist ihr Einsatz zur Glättung des Konjunkturzyklus? Unterscheiden sich die Effekte von fiskalpolitischen Stimuli abhängig von der aktuellen Auslastung einer Ökonomie? Diese wirtschaftspolitisch relevanten Fragen werden kontrovers diskutiert und über die optimale Ausgestaltung fiskalpolitischer Impulse hinsichtlich ihres Umfangs, ihrer Terminierung und der verwendeten Instrumente wird in der Literatur heftig gestritten.

Ziel dieses Papieres ist es, den üblicherweise in der Literatur zu findenden linearen Analysen der deutschen Fiskalpolitik eine weitere Dimension hinzuzufügen, welche asymmetrische Reaktionen auf fiskalpolitische Schocks abhängig von ihrer Größe, ihrer Richtung und und ihrer Terminierung im Konjunkturzyklus erlaubt. Dazu schätzen wir ein vektorautoregressives "Schwellenwert-Modell", welches die Analyse nicht-linearer Effekte durch eine Einteilung der empirischen Beobachtungen in zwei unterschiedliche, in Abhängigkeit von einem Schwellenwert definierte Regime ermöglicht. Innerhalb jedes dieser zwei Regime wird dann ein lineares Modell angenommen. Im Basismodell verwenden wir die Produktionslücke als Schwellenwert, da diese den Konjunkturzyklus in Phasen der Unter- und der Überauslastung aufteilt - jene beiden Regime, in denen wir unterschiedliche Effekte von Fiskalstimuli erwarten. Um die diskretionären fiskalischen Schocks zu identifizieren verwenden wir exogen bestimmte Elastizitäten, die das Wirken der automatischen Stabilisatoren abbilden. Unsere Analyse zeigt, dass die kurzfristigen Fiskalmultiplikatoren in Deutschland generell begrenzt sind und dass die jeweilige Position im Konjunkturzyklus einen wichtigen Einfluss auf die Wirksamkeit von Fiskalstimuli hat.

In einem linearen Referenzmodell ergibt sich für Kürzungen von Steuern und Sozialabgaben und für Ausgabenerhöhungen zunächst ein kurzfristiger Multiplikator von rund 0,7 - was im Bereich der Ergebnisse ähnlicher Studien für Deutschland liegt. Unser Schwellenwert-Modell ermöglicht darüber hinaus grundlegend neue Einsichten in die Effekte von Schocks in Abhängigkeit von ihrer Terminierung im Konjunkturzyklus. Wichtigstes Ergebnis ist dass die Ausgabenmutliplikatoren in Zeiten der Unterauslastung deutlich größer sind als in Zeiten der Überauslastung. Diskretionäre Einnahmenschocks dagegen haben einen insgesamt geringeren Effekt als Ausgabenschocks. Hinsichtlich der Terminierung im Konjunkturzyklus ist der Effekt von Einnahmenschocks im oberen Regime größer als im unteren Regime. Diese Ergebnisse erweisen sich als robust gegenüber zahlreichen getesteten Modifikationen des Modells - einschließlich einer anderen Spezifizierung des Schwellenwertes.

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The Impact of Fiscal Policy on Economic Activity over the Business Cycle - Evidence from a Threshold VAR Analysis[1]

1 Introduction

What are the effects of fiscal policy on economic growth? How effective is it in smoothing the business cycle? Does the state of the business cycle matter for the effects of fiscal policy shocks on GDP? These policy-relevant macroeconomic questions are highly controversial, and the optimal fiscal policy action with respect to the size, timing and the policy mix is the topic of fierce debate in the literature.

The financial turmoil in 2008/2009 has further strengthened the interest of governments, central banks and academia in the role of fiscal policy. The traditional monetary transmission mechanism is weak and monetary policy alone seems unable to counter the huge contraction of demand. Furthermore, many countries have nearly reached the zero lower bound, with no more room to reduce central bank interest rates further. As a consequence, huge fiscal stimulus packages have been introduced – in Germany as well as in most industrialised countries worldwide. And although the belief is strong that these packages helped many countries to recover from the crisis, our knowledge of the effectiveness of fiscal stimuli in such downturns – based on the theoretical and empirical literature – is still very limited. This paper seeks to contribute to the empirical literature on fiscal policy in Germany by adding an additional dimension to the usual linear analyses, allowing for asymmetries of fiscal policy shocks on growth depending on their size, their direction and their timing with respect to the business cycle.

In the theoretical literature we find strongly diverging positions with respect to the general effectiveness of fiscal stimuli. For example, standard Real Business Cycle (RBC) models expect an increase in government consumption to be completely offset by a reduction of private consumption (see Baxter and

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King 1993, Christiano and Eichenbaum 1992 or Fatás and Mihov 2001). On the other hand, standard Keynesian models argue that consumers are non-Ricardian[2] and a government consumption shock increases private consumption and GDP (Blanchard 2001). However, so far little research effort has been spent on the question of whether the effectiveness of fiscal policy might vary depending on macro-economic circumstances. These effects can best be covered in a non-linear policy analysis.[3]

There are several reasons why the reaction to fiscal stimuli can be non-linear. Looking at the supply side of the economy, we can distinguish periods of positive and negative output gaps. The traditional crowding out argument (see Buiter 1977), stating that government expenditure replaces private spending, is generally applicable in times of a positive output gap but less so in times when output is below potential and excessive capacities in the economy are available. This gives fiscal policy the chance to activate unused factors of production.[4]

We also find several arguments for a non-linear impact analysis on the demand side. For example, Drazen (1990) argues that the effects of fiscal policy depend on the size and persistence of the fiscal impulse, because both influence the signalling effect with respect to the fiscal policy that is to be expected in the future (see Giavazzi et al. (2000) for empirical support).[5] Additionally, in times of high negative output gaps and high unemployment individuals and firms are facing tighter credit constraints, as banks eliminate credit lines or increase the risk premia on interest rates for loans. Severely credit-constrained borrowers tend to adjust spending substantially in response to even a contemporaneous change in disposable income, which can even result

[2]The importance of non-Ricardian households for fiscal policy effects is discussed in Coenen and Straub (2005), among others.

[3]Corsetti et al. (2010) argue in favour of non-linear effects of fiscal policy, with especially high fiscal multipliers after strong recessions. Christiano et al. (2009) state that fiscal policy is most effective in the case of very low interest rates (which are likely to occur in times of high negative output gaps).

[4]Along these lines, Knüppel (2008) analyses the consequences of an inclusion of capacity constraints in the RBC framework by means of a Markov switching model. He argues that those capacity constraints are not binding in recessions, leaving economic agents more room to react to policy measures.

[5]The strong effects of the German government's – massive fiscal stimulus packages – including the "cash for clunkers" ("Abwrackprämie") program – as well as financial market stabilisation and the guarantee of deposits during the 2008/09 economic downswing can be see as examples for such a signalling.

from a change in interest rates (see for example Jääskelä 2007). Although the analysis of credit constraints has been applied mostly to monetary policy research (see for example Blinder 1987, Galbraith 1996, Weise 1999, Balke 2000 and Calza and Sousa 2006), there is little reason to doubt that fiscal policy can influence disposable income and thus consumption – especially that of credit-constrained households – by tax cuts or by increases in transfers to the most severely credit-constrained consumers and firms (for a discussion see Galì et al. 2007 or Roeger and in't Veld 2009).

If any of the arguments for non-linearity applies, the linear VAR framework, which dominates the empirical literature, is not adequate. Tying a non-linear economy to a linear VAR framework can lead to misleading inferences with respect to its dynamics. Several approaches to model time series non-linearities can be found in the literature, including Markov switching, smooth transition and threshold autoregressive models. We adopt the latter approach, which is characterised by a separation of the observations into different regimes based on a threshold variable. Within each regime, the time series is then assumed to be described by a linear model. In our multivariate context we use the multivariate Tsay (1998) procedure to test for non-linearity in the data, using the output gap or GDP growth as the threshold variable. In both cases the test rejects linearity. Consequently, the threshold impulse responses (IR) are generated using the general IR modelling introduced by Koop et al. (1996), which allows for the non-linear propagation of shocks across regimes. Using this framework, we can examine the sensitivity of economic activity to fiscal policy shocks depending on the business cycle as well as of the size and the direction of the shock.[6]

In the baseline specification, we use the output gap as the threshold variable[7], as it divides economic development in phases of under- and overutilisation – the two regimes under which we expect the effects of fiscal stimuli to

[6]Tong first proposed a threshold autoregressive (TAR) model in the late 1970s and refined it during the early 1980s (Tong 1978, Tong and Lim 1980 and Tong 1983). Tsay (1998) and Hansen (1996, 1997) made the threshold model applicable to a multivariate framework which is now widely used in time-series analysis, as in Hansen (1999a, 1999b, 2000), Gonzalez and Gonzalo (1997), Gonzalo and Montesinos (2000), Gonzalo and Pitarakis (2002), among various others.

[7]Koske and Pain (2008) demonstrate that the output gap plays an important role not only for ex-post evaluation of policies but as well for real-time policy decisions. Furthermore they argue that the output gap is a reliable real-time indicator in the short run.

differ.[8]

To identify discretionary fiscal policy shocks in our non-linear model, we employ structural identification following Blanchard and Perotti (2002) and hence use exogenously determined elasticities for the working of automatic stabilisers. However, we extend their approach and estimate the impulse responses based on time-varying elasticities. This allows us to identify discretionary fiscal policy shocks even more reliably.

Our research shows that short-term fiscal multipliers in Germany are in general moderate and that the state of the business cycle strongly matters for the effects of fiscal policy shocks. In a linear benchmark model, the analysis finds that the effect on GDP of reductions in tax and social security contributions and of increased spending each corresponds to a short-term fiscal multiplier of around 0.7, putting it in the range of other empirical results for Germany. In addition the threshold model derives fundamentally new insights on the effects of shocks, depending on their timing with respect to the business cycle. Most importantly, fiscal spending multipliers are much larger in times of a negative output gap but have only a very limited effect in times of a positive output gap. Discretionary revenue policies, on the other hand, have generally a more limited effect. With respect to the cycle, their impact is larger in the upper than in the lower output gap regime. Various robustness checks, including a different threshold specification, do not influence the resulting policy implications substantially.

The paper is organised as follows. Section 2 presents the main recent empirical contributions in the literature, specifically for Germany. Section 3 subsequently presents the empirical approach, and section 4 includes a detailed description of the dataset. The empirical strategy for structural identification and the estimation results are presented in section 5. Various robustness checks are carried out in section 6, and section 7 concludes.

2 Empirical Literature

The literature on fiscal policy multipliers derives strongly diverging results for the effects of fiscal stimuli on economic activity. The methods applied in empirical analyses range from model simulations using different estimation

[8]Within the robustness checks we pursue an analysis that employs a three-quarter moving average of GDP growth itself as threshold.

and calibration techniques – such as the IMF Multimod model, the OECD Interlink or the ESCB New Area Wide Model - to reduced form equation parameter estimation techniques. Surveys of the empirical literature, which can be found in Hemming (2002), Spilimbergo et al. (2009) and Coenen et al. (2010), demonstrate the great bandwith of spending and revenue multipliers. Depending on the method and model specification, one-year fiscal spending multipliers range between 0.2 and 2 for the US, while estimates for Germany lie between -0.2 and 5.1.[9]

While no consensus on the impact of fiscal policy on economic activity has been reached, researchers generally agree on the importance of interdependencies between fiscal and economic developments. Within the empirical literature these interdependencies are most frequently analysed in vector autoregressive (VAR) models. A focus in this literature lies on the identification of discretionary fiscal policy shocks, for which most researchers rely on some form of structural identification.[10] Most prominent are the recursive identification approach (Cholesky ordering), the sign-restrictions approach[11] and the structural VAR approach using the identification procedure proposed by Blanchard and Perotti (2002) (for a discussion on Cholesky ordering and sign-restrictions see Perotti 2004).

In the present paper we follow Blanchard and Perotti (hereafter BP). BP identify automatic stabilisers by incorporating exogenously given information about the elasticities of revenues and expenditures with respect to GDP. In their 2002 paper, they analyse the US economy between 1960 and 1997 and find that expansionary fiscal shocks increase output with a long-term fiscal multiplier close to unity. Furthermore, they find negative effects of tax and spending increases on investment.

It is important to note that the results obtained from VAR studies depend on the specific country analysed, as fiscal policy, the structure of the economy and the interplay of economic and fiscal developments differ substantially

[9]However, the value of 5.1 is derived by Perotti (2006) only for public investment spending.

[10]The narrative or event-study approach can also be used for identification. It identifies discretionary policy actions via specific historical events, such as contemporaneous press reports, wars or war-related military spending, tax changes and elections. For further discussion see Ramey and Shapiro (1998), Edelberg et al. (1999), Eichenbaum and Fisher (2005), Ramey (2006) and Favero and Giavazzi (2009) or Romer and Romer (2010).

[11]For a current application to US data see Mountfort and Uhlig (2009), who find the highest multipliers for deficit-financed tax cuts.

across countries. Therefore, the analysis of shocks based on German data is likely to yield different results than those for the US.[12] For Germany only a few attempts analysing fiscal policy shocks are available, and all but one of them employ the BP identification approach. The studies include Höppner (2001), Perotti (2004), Heppke-Falk et al. (2010) and Bode et al. (2006). Afonso and Sousa (2009) employ a recursive identification.[13]

Höppner (2001) uses quarterly cash data from 1970 to 2000 in a three-variable VAR (government expenditures including government consumption, investment and public transfers, such as subsidies; tax revenues from direct and indirect taxes; and GDP). Based on his estimations, the effects of tax shocks are by far larger than the effects of spending shocks. He estimates a significant fiscal multiplier for a tax increase of -1.59 in the long run (meaning that a tax increase by one unit reduces GDP by more than 1.5 units), while the multiplier for an expenditure shock equals only 0.23 (and is insignificant).

Perotti (2004) applies the BP approach to various countries, including Germany, and analyses the effects of fiscal shocks on output, inflation and the ten year nominal interest rate. In his data set public spending is restricted to public investment and consumption and does not include interest spending, while the net revenue series is calculated by subtracting transfers from overall revenues. Perotti argues that tax-financed transfers have the reverse effects of taxes and should therefore be substracted from overall taxes. For Germany Perotti uses quarterly West German data from 1960 to 1989. Based on these data definitions, he finds a short-term multiplier of only around 0.5 following a positive shock of government spending, which fades out quickly after the first year.

Furthermore, Perotti identifies a structural break in 1974 and re-estimates the model in two subperiods (1960-1974 and 1975-1989). The structural break influences especially the effect of tax shocks. In the first subsample he estimates a short-term multiplier of 0.19 (after 4 quarters) for tax increases – indicating an expansionary effect of tax hikes - while in the second subsample the tax multiplier for a positive shock is -0.03.

Heppke-Falk et al. (2010) follow the Perotti (2004) data definitions and

[12] This is demonstrated by Burriel et al.(2010), who compare the effects of fiscal policy in the US and the Euro area using the BP approach and find a much higher persistency of fiscal shocks in the US.

[13] A detailed comparison of the first three VAR studies for Germany can be found in Roos (2007).

Table 1: German VAR Analysis, Impact of Fiscal Shocks on GDP

	Sample	**short-run**	**long-run**
Effect of an increase in government spending on GDP			
Höppner (2001)	1970-2000	positive	insignificant
Perotti (2004)[a]	1960-1989	positive	insignificant/negative
Heppke-Falk et al. (2010)	1974-2008	positive*	positive*
Bode et al. (2006)	1991-2005	positive	insignificant
Afonso and Sousa (2009)	1980-2006	negative	negative
Effect of a decrease in government revenues on GDP			
Höppner (2001)	1970-2000	positive	positive
Perotti (2004)[a]	1960-1989	negative/insignificant	insignificant
Heppke-Falk et al. (2010)	1974-2008	positive**	insignificant
Bode et al. (2006)	1991-2005	positive	insignificant
Afonso and Sousa (2009)	1980-2006	insignificant	negative

* Significant only for government investment; in sum with government consumption insignificant
** Significant only for direct taxes; net revenue is insignificant
a : Two subsamples are tested, the first 1960-1974, the second 1975-1989. If the results are different, they are shown for the first and the second subsample, respectively.

estimate a VAR covering a longer time series of quarterly German cash data between 1974 and 2008. In their three variable specifications (GDP, expenditure and revenues), they find a positive reaction of GDP to spending increases that is significant only in the contemporaneous quarter, with a spending multiplier of around one. Like Perotti's first subsample, they find a positive reaction of GDP to a revenue increase with a value of 0.12 in the quarter the shock occurs.

Bode et al. (2006) estimate the structural three-variable VAR including only pan-German data from 1991-2005. Based on a data definition similar to that of Perotti (2004) and Heppke-Falk et al. (2010) they find a significant positive effect of spending on GDP, with a one-year fiscal multiplier of around 0.5, as well as a significantly negative but in size slightly smaller multiplier for the effects of a revenue increase.

The latest available study for Germany is provided by Afonso and Sousa (2009), who use a Cholesky decomposition for the structural identification in a nine-variable VAR covering data from 1980 to 2006. They further add a feedback rule in order to cover government debt dynamics, and find a small but significant fall in GDP after a spending shock. The reaction of GDP to a revenue increase is small but positive, supporting the finding by Perotti (2004) for the first subsample. They explain these results with a "crowding-out" effect of public spending, but also a "crowding-in" effect of public revenues, with both consumption and investment increasing after the shock as a result of fiscal consolidation.

In summary, all the studies which use the BP identification scheme find a small positive fiscal multiplier for government spending increases, while Afonso and Sousa (2009) estimate a small but negative effect based on a Cholesky identification. With respect to tax cuts, the results of the discussed studies differ strongly. Tax cuts increase GDP in the studies by Höppner (2001) and Bode et al.(2006), while Heppke-Falk et al. (2010) and Afonso and Sousa (2009) find contractionary effects. Perotti's (2004) results are sensitive to the subsample analysed. Depending on the timespan covered, the impulse responses display clear differences and therefore indicate a variability of the impact of fiscal shocks in different decades and macroeconomic environments.

Closely related to this last point, a drawback of all the empirical studies presented is that they are bound to a linear estimation framework. That is, they do not account for any asymmetry in the variable responses or the relationship between the macro variables themselves. However, since they provide a good starting point for a fiscal policy analysis, we use the linear modelling as a benchmark and extend it to a non-linear threshold framework in order to account for the possible asymmetries discussed in the introduction.[14]

3 Methodology

Threshold VARs are piecewise linear models with different autoregressive matrices in each regime. The regimes are determined by a transition variable, which is either one of the endogenous variables or an exogenous variable (Hansen 1996, 1997, Tsay 1998). In general it is possible to obtain more than one critical threshold value and therefore more than two regimes, but for simplicity we will focus on a model with two regimes only.[15]

Let a set of k stationary endogenous variables with $y_t = (y_{1t}, ..., y_{kt})'$ and T observations describe a VAR of finite order p

$$y_t = \Gamma_0 + \Gamma_1 y_{t-1} + ... + \Gamma_p y_{t-p} + u_t \ , \tag{1}$$

where Γ_0 is a k-dimensional vector containing deterministic terms such as a constant, a linear time trend or dummy variables. Γ_i with $i = 1, ..., p$ are squared coefficient matrices of order k, and u_t is a sequence of serially uncorrelated random vectors with mean zero and covariance matrix $Cov(u_t) = \Sigma_u$. We can rewrite equation (1) in the compact form

$$y_t = \Gamma X_t + u_t \ , \tag{2}$$

[14] An interesting non-linear analysis of German fiscal policy using a different methodology is Höppner and Wesche (2000), who apply a Markov-switching approach to fiscal policy effects in Germany and find time-varying effects.

[15] The two-regime setup is also best for our fiscal policy analysis over the business cycle since the general concept of the business cycle is based on a distinction between an upper (positive output gap) and a lower (negative output gap) regime.

with $\Gamma = (\Gamma_0, \Gamma_1, ..., \Gamma_p)$ and $X_t = (1, y_{t-1}, ..., y_{t-p})'$. Following this notation, a threshold VAR is represented by

$$y_t = \Gamma_1 X_t + \Gamma_2 X_t I[z_{t-d} \geq z^*] + u_t \ . \tag{3}$$

z_{t-d} is the threshold variable determining the prevailing regime of the system, with a possible lag d. $I[\cdot]$ is an indicator function that equals 1 if the threshold variable z_{t-d} is above the threshold value z^* and 0 otherwise. The coefficient matrices Γ_1 and Γ_2, as well as the contemporaneous error matrix u_t are allowed to vary across regimes. The delay lag d and critical threshold value z^* are unknown parameters and determined alongside the parameters.

In the linear and the non-linear model we face the problem that the contemporaneous errors are not uncorrelated with each other, i.e. Σ_u is not a diagonal matrix. In this case fiscal policy shocks are not identified, since the correlation of the error terms indicate that a shock in one variable is likely to be accompanied by a shock in another variable. Following Blanchard and Perotti (2002), we identify the policy shocks using an AB model for structural identification in the error-covariance matrix. The linear model thus becomes[16]

$$Ay_t = CX_t + B\varepsilon_t \ , \tag{4}$$

assuming that $u_t = A^{-1}B\varepsilon_t$ where $\Sigma_u = A^{-1}BB'A^{-1'}$ and B is a $k \times k$ matrix of parameters.[17]

The non-linear model can be correspondingly written as

$$A_n y_t = C_1 X_t + C_2 X_t I[z_{t-d} \geq z^*] + B_n \varepsilon_t^n \ , \tag{6}$$

where A_n and B_n differ from A and B in the linear model, since they are based on the regime-dependent errors. As before, $\Gamma_i = A_i^{-1} C_i$, and $Cov(u_t^n) = \Sigma_n = A_n^{-1} B_n B_n' A_n^{-1}$. The exact identification procedure is explained in section 5.3.

Before estimating a non-linear model we need to test if the system is indeed non-linear. Following the testing approach developed by Tsay (1989, 1998) we first identify a series z representing the threshold variable with $-\infty = z_0 < z_1 < ... < z_{s-1} < \infty$. z needs to be stationary with a continuous distribution, restricted to a bounded set $S = [\underline{z}, \overline{z}]$, where S is an interval on the full sample

[16] A detailed description and derivation of the AB model, as well as the corresponding A and B models can be found in Amisano and Giannini (1997), Lütkepohl (2005) and Lütkepohl and Krätzig (2004). Further applications of the AB model can be found in Pagan (1995), Breitung and Lütkepohl (2004) and Blanchard and Perotti (2002).

[17] Alternatively, the AB model can be represented in the error component form

$$\overline{A} u_t = B\varepsilon_t \ . \tag{5}$$

range of the threshold variable. The interval should be trimmed in order to assure a minimum number of observations in each subsample.

The lag order p and the threshold lag d need to be determined a priori, which in case of p is achieved by applying the normal information criteria in the linear VAR estimation. For the choice of d we will rely on economic reasoning.

The regression framework of equation (2) can be rewritten as

$$y_t' = X_t'\Gamma + u_t', \qquad t = h+1, ...n \ , \tag{7}$$

where, as before, Γ denotes the parameter matrix, $X_t = (1, y_{t-1}', ..., y_{t-p}')'$, and $h = \max(p, d)$.

We reorder the cases according to the threshold variable z_{t-d}, denoting the i-th smallest element of the interval S as $z(i)$ (equals the m-th smallest value of all observations.[18]) The arranged regression can be written in the form

$$y_{t(i)+d}' = X_{t(i)+d}'\Gamma + u_{t(i)+d}', \qquad i = 1, ..., n-h \tag{8}$$

where $t(i)$ is the time index of $z(i)$. In short, we order the values of the threshold variable according to its size and split the sample according to the threshold value $z(i)$. The model is estimated with the m observations below $z(i)$ by OLS to obtain $\hat{\Gamma}_m'$. Subsequently, OLS is performed again for the first $m+1$ observations with $z(i+1)$ and so on. The result is a sequence of OLS regressions, each using the first m ranked observations. For each of these regressions, we keep the one-step ahead predictive and standardised residuals $\hat{\varrho}$ and $\hat{\eta}$, calculated with

$$\hat{\varrho}_{t(m+1)+d} = y_{t(m+1)+d} - \hat{\Gamma}_m' X_{t(m+1)+d} \tag{9}$$

$$\hat{\eta}_{t(m+1)+d} = \frac{\hat{\varrho}_{t(m+1)+d}}{[1 + X_{t(m+1)+d}'(\Sigma_{i=1}^m X_{t(i)+d}X_{t(i)+d}')^{-1}X_{t(m+1)+d}]^{1/2}} \ . \tag{10}$$

In order to analyse threshold behaviour we test for white noise in the regression

$$\hat{\eta}_{t(l)+d}' = X_{t(l)+d}'\phi + w_{t(l)+d}', \qquad l = m_0+1, ..., n-h \tag{11}$$

where m_0 denotes the starting point of the recursive least squares estimation. If $\phi = 0$ the data is generated by a linear model.[19] Consequently, we

[18] Remember that the interval $S = [\underline{z}, \bar{z}]$ is trimmed. The trimming percentage is the percentage of observations of the whole sample below m_0. m_0 corresponds to $z(i)$ with $i = 1$.

[19] The sequential OLS estimates are consistent estimates of the lower regime parameters as long as the last observation used in the regression does not belong to the upper regime. In this case, the predictive residuals are orthogonal to the corresponding regressor and y_t is linear. However, if y_t follows a threshold model, the predictive residuals will not be white noise and correlated with $X_{t(i+d)}$. As a consequence the least squares estimator would be biased.

test the hypothesis $H_0 : \phi = 0$ against the alternative $H_1 : \phi \neq 0$. Tsay (1998) proposes the following test statistic:

$$C = [n - h - m_0 - (kp + 1)]\{\ln[\det(S_0)] - \ln[\det(S_1)]\} \tag{12}$$

with $det(\cdot)$ being the determinants of

$$S_0 = \frac{1}{n - h - m_0} \sum_{l=m_0+1}^{n-h} \hat{\eta}_{t(l)+d} \hat{\eta}'_{t(l)+d} \tag{13}$$

and

$$S_1 = \frac{1}{n - h - m_0} \sum_{l=m_0+1}^{n-h} \hat{w}_{t(l)+d} \hat{w}'_{t(l)+d}. \tag{14}$$

The test statistic is asymptotically chi-square with $k(pk + 1)$ degrees of freedom. If the test detects a threshold in the DGP, the coefficients can be estimated conditional on a sum of least square minimisation over both regimes. That is, for a given value of z, the LS estimate of $\Gamma_{(i)}$ for regimes $(i) = 1, 2$ is

$$\hat{\Gamma_{(i)}}(z) = (\sum_t^{(i)} X_t(z) X_t(z)')^{-1} (\sum_t^{(i)} X_t(z)) y_t \tag{15}$$

with residuals $\hat{u}_{t(i)}(z) = y_t - X_t(z)' \hat{\Gamma_{(i)}}(z)$, and residual variance

$$\hat{\sigma}^2_{(i)}(z) = \frac{\sum_t^{(i)} \hat{u}^{\,2}_{t(i)}(z)}{n_{(i)} - k}, \tag{16}$$

where $\sum_t^{(i)}$ is the sum of all observations in regime (i) and $n_{(i)}$ is the number of observations in regime (i). The sum of squared residuals is

$$\hat{R}(z) = \hat{R}_{(1)}(z) + \hat{R}_{(2)}(z)\ , \tag{17}$$

where $\hat{R}_{(i)}(z) = (n_{(i)} - k)\hat{\sigma}^2_{(i)}(z)$. Finally, the conditional threshold value $\hat{z*}$ is obtained by

$$\hat{z*} = argmin_z \hat{R}(z)\ . \tag{18}$$

In the case of a test result that suggests a threshold effect, we wish to apply an impulse response (IR) analysis that is able to capture non-linearities. Gallant et al. (1993), Koop (1996) and Koop et al. (1996) point out that in non-linear models the effect of a shock depends on the entire history of the system up to the point when the shock occurs. Thus, it is necessary to model the IRF conditional on this history, and as a consequence conditional on the size and the direction (sign) of the shock.[20] For this purpose we cannot apply linear IR functions, as they are history-independent, i.e. they do not depend on a particular history of the data up to time t. They are symmetric in the sense that a shock of $-\varepsilon_{t-m}$ has exactly the opposite effect of a shock of size $+\varepsilon_{t-m}$ and they are linear as they are proportional to the size of the shock. Hence, they cannot be applied here. Instead, we will model generalised impulse response functions (GIRF) introduced by Koop et al. (1996), which address these problems and which are applicable to both linear and non-linear models.

Defining ε_t as a shock of a specific size, m as the forecasting horizon and Ω_{t-1} as the history or information set at time $t-1$, Koop et al. (1996) define the GIRF as the difference between two conditional expectations with a single exogenous shock:

$$GIRF = E[X_{t+m}|\varepsilon_t, \varepsilon_{t+1} = 0, ..., \varepsilon_{t+m} = 0, \Omega_{t-1}] \\ - E[X_{t+m}|\varepsilon_t = 0, \varepsilon_{t+1} = 0, ..., \varepsilon_{t+m} = 0, \Omega_{t-1}] \ . \quad (19)$$

The GIRF allows the regimes to switch after a shock, a characteristic that is responsible for the different outcomes of positive and negative shocks as well as their size.[21]. We are thus able to relax the assumption that shocks occurring in a recession are just as persistent as shocks occurring in an expansion. The calculation of the GIRF induces some computational effort and the exact algorithm is described in Appendix (A).

4 The Data

To keep the analysis as parsimonious as possible, we include only three variables: government spending, government revenue and GDP.[22] In the non-linear specification, we need an additional threshold variable in order to distinguish between "good" and "bad" economic times. Here we rely on the output gap as an indicator for the different phases of the economic cycle, which is generally

[20] In fact, non-linear time series models do not have a Wold representation and the assumption that no shocks occur in intermediate periods may give rise to misleading inferences concerning the propagation mechanism of the model.

[21] GIRF were applied in several empirical applications, for example in Balke (2000), Atanasova (2003), Root and Lien (2003), Jääskelä (2007) A detailed description of GIRF for the univariate case can also be found in Potter (2000).

[22] A five-variable model that contains investment and consumption might allow us to study the transition of policy shocks in the economy in more detail, but estimating a five-variable model is impractical because the number of coefficients in the linearity test and the TVAR rises in proportion to the number of coefficients in the standard linear model. This affects the size and power of the tests. Therefore, the present paper will restrict itself to a three-variable specification and leaves the proposed extension to future work.

seen not only as a reliable ex-post but also as a reliable real-time indicator for policy-makers (see Koske and Pain 2008).

The data is compiled from the Deutsche Bundesbank's national accounts database and defined according to the European System of National Accounts (ESA) 1979 and 1995. The advantage the national accounts data has over cash data is that its data are adjusted for special events and distortions caused, for example, by lagged payments of taxes.[23] Additionally, we remove the effect of the liquidation of the German Treuhand in 1995 (199.6 billion Euro in total) and revenues from the auction of the UMTS licenses in 2000 (50.8 billion Euro).

The dataset is quarterly and covers the period from the first quarter of 1976 to the fourth quarter of 2009, giving 136 observations. Generally we would have been able to start our analysis in the first quarter of 1970, but we decided to exclude the first five years in order to avoid a structural break due to a policy shift after 1975.[24] The structural break at reunification is eliminated by prolonging the series for reunified Germany backwards with West German growth rates. Our estimations are based on data in real terms (all three variables are deflated by the GDP deflator with a value of 1 in the year 2000) and seasonally adjusted by applying the BV 4.1 procedure of the German Federal Statistical Office.[25]

The output gap is calculated with the Hodrick-Prescott filter ($\lambda = 1600$) applied to the real GDP series. To avoid a distortion of the results at the lower and upper bound, we prolong the series with its own linear trend in the past (1960-1970) and the future (2009-2019). The real output gap variable is then calculated as the difference between actual real GDP and potential real GDP (measured by the HP-filtered trend) as a percentage of potential GDP.

The fiscal series offer a great variety of possible compositions. Seminal studies such as BP (2002) and Perotti (2004) define public spending very narrowly as government investment plus government consumption, and public revenues as general government revenues (excluding social security) minus transfers. Although many papers follow this definition (see the discussion in section 2), we argue that it is not well-suited for an analysis of fiscal policy in Germany, since social insurance accounts on average for more than 40% of total revenues and

[23] See ECB (2007) for a definition of government finance statistics according to ESA and standard methods of national accounting.

[24] Before 1976 the German government - inspired by Keynesian macro-economics - aimed at an active stabilisation of the business cycles via frequent temporary tax and expenditure measures. The most important measure aimed at economic stimulation was the introduction of an investment bonus of 7.5% for all investment in machinery and equipment realised between 1 December 1974 and 30 June 1975. These measures contributed to a high volatility of tax revenues and spending, which is reflected especially in the growth rates of the series, with a breakpoint identified by Perotti (2004), for instance, to be 1974:4.

[25] A discussion of the methodology applied in the "Berliner Verfahren" can be found at http://www.uni-mannheim.de/edz/pdf/eurostat/06/KS-DT-06-012-EN.pdf.

Table 2: Unit Root Tests

	ADF			Phillips-Perron	
	Lags (SIC)	t-statistic	p-value	t-statistic	p-value
Revenues	7	-4.274	0.0007	-8.984	0
Expenditures	3	-5.388	0	-11.721	0
GDP	1	-4.914	0.0001	-6.999	0
Output Gap	9	-5.155	0	-3.705	0.005

H_0: series has a unit root.

for a large part of overall public spending. Furthermore, economic stimulation is often explicitly pursued via the social security system. For example, during the 2008/2009 recession large parts of the German fiscal stimulus were implemented through deficit-financed cuts in social security contributions. Even if considered as a pure redistribution (such as in Perotti 2004, Heppke-Falk et al. 2010, or Bode et al. 2006), the social security system can have far-reaching effects on private consumption based on differences in the savings rate of net payers and net recipients. These consumption effects, in turn, can influence overall growth. Thus, we include social insurance in our analysis.

Unemployment spending is, due to its strong dependence on the business cycle, subtracted from the expenditure side and enters the revenue series with a negative sign in order to satisfy the precondition of the BP structural identification approach that automatic stabilisers only apply on the revenue side. The treatment of public interest spending differs over the existing studies. Perotti (2004) and Fernández and Cos (2006) argue that interest spending is not part of discretionary fiscal policy and should be excluded from the data series, while Blanchard and Perotti (2002) argue that interest payments should be included as they reflect a "normal" transfer of resources from the public to the private sector (and thereby influence economic growth). We follow the approach of Perotti (2004) and subtract interest payments from the expenditure and the revenue variable.[26]

Taken together, this leaves us with a public spending series defined as total current public spending excluding net interest (i.e. interest spending minus dividends received by the government) and unemployment insurance spending. Our revenue series includes social security contributions but is diminished by net interest spending and unemployment insurance spending.

Except for the output gap (which is stationary), we apply the logarithm to all series and take the first differences in order to achieve stationarity. The resulting quarter-to-quarter growth rate series and the output gap are plotted in figure 1. All series tend to revert to their mean.

[26]This approach is in line with other studies for Germany, such as Heppke-Falk et al. (2010) and Bode et al. (2006).

Figure 1: Growth Rates of Series

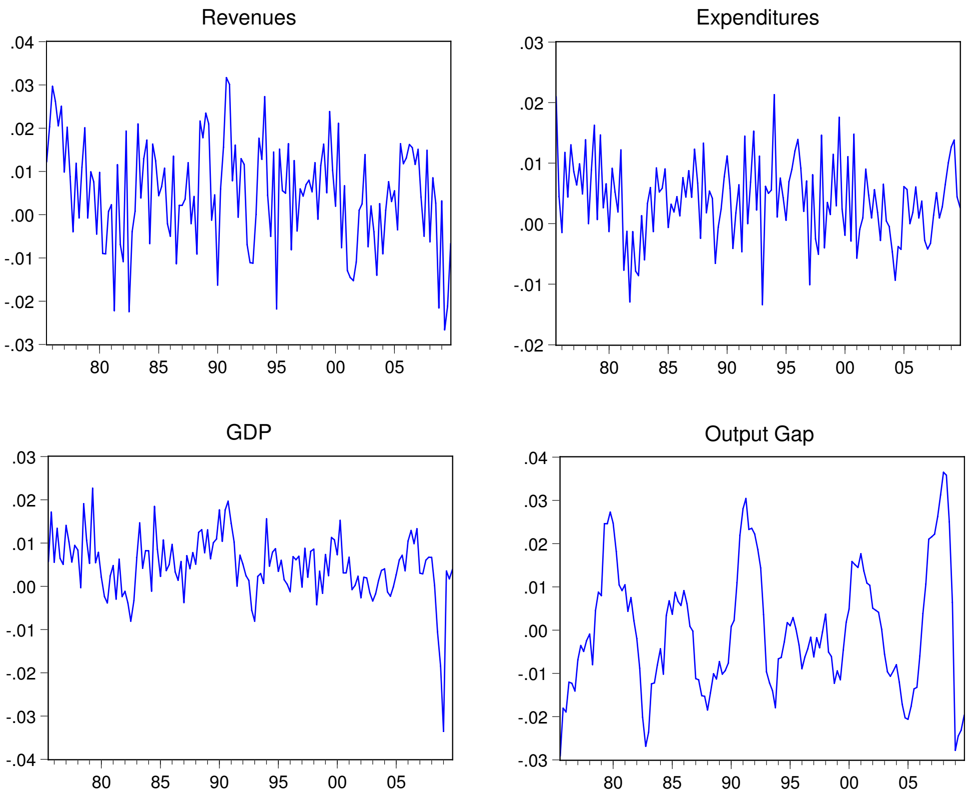


Table 3: Descriptive Statistics

Variable	Mean	Maximum	Minimum	Std. Dev.
Revenues	0.0049	0.031	-0.026	0.012
Expenditures	0.0039	0.021	-0.013	0.007
GDP	0.0048	0.023	-0.033	0.007
Output Gap	-0.0001	0.036	-0.029	0.014

We also employ the standard unit-root methodology, i.e. the Augmented Dickey-Fuller (ADF) and Phillips-Perron test. It is necessary to choose the number of augmentation lags to account for serial correlation in the Dickey-Fuller regressions, for which we use the Schwarz Information Criterion (SIC). For all four series, both tests include a constant but no trend. Table 2 shows the results for the growth rates. The values indicate that the series are stationary by rejecting the null hypothesis of the existence of a unit root. Additionally, descriptive statistics of the three series are shown in table 3.

5 Estimation

5.1 Model Specification

The VAR of equation 1 consists of a three-dimensional system of endogenous variables $y_t = [T_t,\ G_t,\ GDP_t]$, with $T_t,\ G_t$ and GDP_t being the growth rates in government revenues, government spending and GDP, respectively. A constant is included in y_t.

For the optimal lag length we conduct various model selection tests, which provide different lag order suggestions. While the Schwarz Information Criterion (SIC) suggests the use of only one lag, the Akaike Information Criterion (AIC) and the Hannan-Quinn (HQ) Criterion suggest the use of four lags and the prediction error the use of six. Although the majority of the criteria propose a higher order, we follow the SIC and specify the benchmark specification with one lag. We base this choice on the same reason for using only three variables: the high cost of estimating additional parameters and therefore of over-fitting in the non-linear model (every additional parameter added decreases the power of the estimation substantially; see for example Hansen (1996) for a Monte Carlo proof).

Using one lag in the VAR, the Breusch-Godfrey Lagrange multiplier test for serial correlation does not reject the null hypothesis of no serial correlation for the tested lag numbers 2 and 5 with p-values of 0.115 and 0.218, respectively. On the other hand, the Portmanteau test does reject the null at least at the 5% level for higher lag values.[27] It is thus important to check the model

[27]However, the same is true if the model is estimated with four and six lags. Therefore we do not base the choice of the lag order on the autocorrelation properties.

Table 4: Tsay Threshold Test

d	Test statistic	p-value[a]	Threshold value
0	19.971	0.0676	-0.001516
1	39.916	0.0000	-0.001510
2	32.138	0.0013	-0.001516

H_0: linearity, H_1: threshold behavior
d: lags in the threshold variable

estimation properties in a profound robustness analysis. Furthermore, since the standard errors might be underestimated, we have to be careful in interpreting the confidence regions. To rule out that the policy implications we will find rely to a great part on imprecise structural identification, we will test the effects of alternative values for a_1 as well as changes in the general identification procedure through the application of the Cholesky decomposition in the robustness checks.

5.2 Threshold Tests

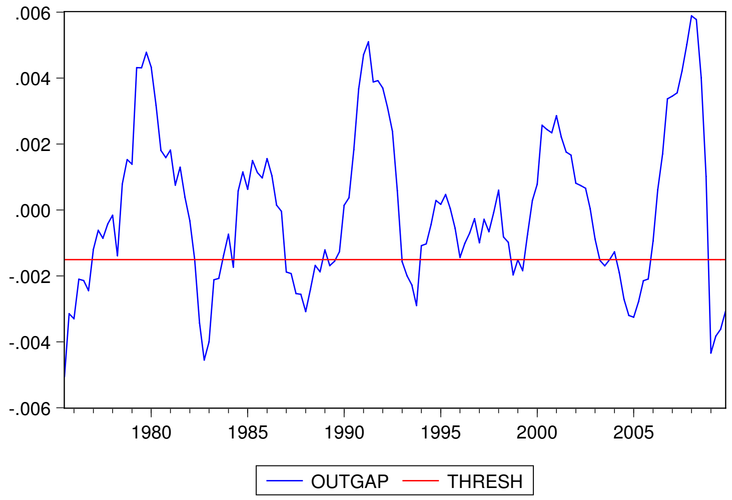
The test results for the null of linearity with one lag in the VAR and different lags in the output gap are presented in table 4. The Tsay test statistic is computed using a 30% trimming percentage and the test rejects linearity of the system for all three threshold specifications. We will continue to use one lag in the threshold variable, in order to account for moderate economic rigidities.

The estimated threshold value for a specification with one lag in the VAR and one lag in the threshold variable is -0.0015. Being in close neighbourhood to zero, this value justifies the classification of the two regimes as representing periods of output above and below its potential level. The two regimes are shown in figure 2. The sample splits into 45 observations in the lower regime and 91 observations in the upper regime, with a total of 15 regime switches. With two of those being of very short length, this gives us approximately six complete business cycles within 39 years.

5.3 Identification

As described earlier, we follow the identification procedure developed by Blanchard and Perotti (2002). In the SVAR representation $\overline{A}u_t = B\varepsilon_t$, $u_t = (gdp_t, g_t, t_t)$ is the vector of reduced-form error terms for the GDP, government spending and revenue equation, respectively. The vector of structural shocks is given with $\varepsilon_t = (\varepsilon_t^{GDP}, \varepsilon_t^T, \varepsilon_t^G)$ with $Cov(\varepsilon_t) = I_3$ and ε_t^{GDP}, ε_t^G and ε_t^T corresponding to the GDP, tax and spending shocks. After estimating the reduced form VAR, we can use the reduced-form residuals u_t to determine the elements of A and B. But prior to that, some identifying assumptions need to

Figure 2: Output Gap Regimes, Threshold Value=0.15%



be made. First, the innovation in the fiscal variables g_t and t_t can be described as a linear combination of three types of shocks, (i) the automatic response of government expenditure and revenue to real output, (ii) the systematic, discretionary response of expenditure to shocks in revenue and of revenue to shocks in expenditure and (iii) the random, discretionary fiscal policy shocks, which are the underlying structural shocks $\varepsilon_t^G$and ε_t^T to be identified. We also think of unexpected changes in GDP (gdp_t) as a function of shocks in government spending, revenue and a structural shock in GDP itself. With these assumptions, we can write:

$$\begin{aligned} t_t &= a_1\varepsilon_t^{GDP} + a_2\varepsilon_t^G + \varepsilon_t^T \\ g_t &= b_1\varepsilon_t^{GDP} + b_2\varepsilon_t^T + \varepsilon_t^G \\ gdp_t &= c_1\varepsilon_t^T + c_2\varepsilon_t^G + \varepsilon_t^{GDP}. \end{aligned} \tag{20}$$

We can rearrange this system to reconstruct the AB representation $\overline{A}u_t = B\varepsilon_t$, with

$$\overline{A} = \begin{pmatrix} 1 & 0 & -a_1 \\ 0 & 1 & -b_1 \\ -c_1 & -c_2 & 1 \end{pmatrix} \quad \text{and} \quad B = \begin{pmatrix} 1 & a_2 & 0 \\ b_2 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}. \tag{21}$$

Using information about the tax and transfer system to determine the coefficients in $\overline{A}$ and B, Blanchard and Perotti apply the following procedure:

I) In the first step institutional information on the German public finance system is used in order to identify the coefficients a_1 and b_1. We have to consider that the two coefficients incorporate two distinct effects of activity on spending and taxes. They capture the automatic stabilisers, which are the automatic effects of economic activity on the fiscal variables under existing

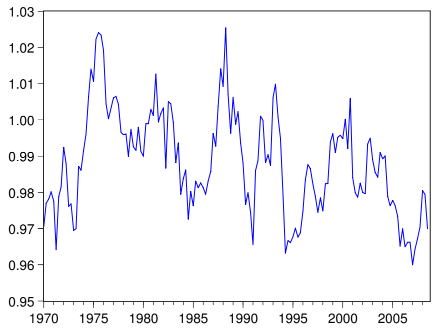


Figure 3: Time-Varying Elasticities

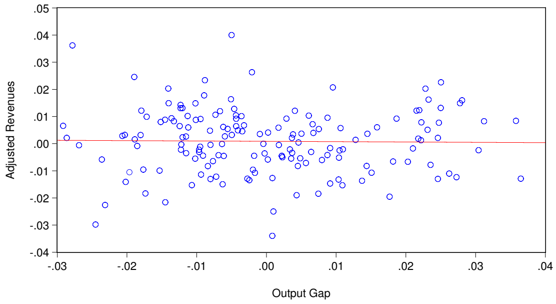


Figure 4: Adjusted Revenue - Output Gap Correlation

fiscal institutions. In addition, they capture any discretionary adjustment of fiscal policy to unexpected exogenous changes in economic activity within the same quarter. As long as we assume that it takes fiscal policy to react some time to changes in GDP due to democratic, legislative and bureaucratic processes in decision making and implementation, the use of quarterly data basically eliminates the second channel. It is thus valid to assume that a_1 and b_1 solely capture the automatic responses of fiscal variables to GDP. They are calculated using the OECD framework by Girouard and André (2005), the difference being that we use quarterly instead of annual data. For the aggregate elasticity of N tax series with respect to output Girouard and André (2005) apply the following formula:

$$a_1 = \sum_{i=1}^{N} \eta_{T_i,B_i} \; \eta_{B_iGDP} \frac{\tilde{T}_i}{\tilde{T}} \tag{22}$$

where $\tilde{T}$ are the net taxes, with $\tilde{T} = \sum_i^N \tilde{T}_i$ and $\tilde{T}_i$ being taxes of type i, which take on a positive value for taxes and a negative value for transfers. η_{T_i,B_i} denotes the elasticity of tax i with respect to its tax base B_i and η_{B_iGDP} denotes the elasticity of the tax base to GDP. The exact calculation of the elasticity a_1 and the taxes and tax bases in use are described in Appendix (C). Following the OECD approach, we find an elasticity around 1, which lies in the middle of elasticities applied in studies relying on similar data.[28]

However, one could object that the shares of the different revenue and expenditure components in net revenues vary strongly over time, which we demonstrate in figure 3. Even if the elasticities of the subcomponents were stable - this would make the application of time-varying elasticities necessary. In this respect we extend the basic BP approach and use the time-varying elasticities instead.

[28] We also estimate the model based on elasticities of 0.5 and 1.5 to test the robustness of our results; see section 5.1.

Additionally, we test the viability of the applied elasticities through correlation between the output gap and the revenue series, which we adjusted for the automatic responses based on the calculated elasticity. A non-zero correlation means that the elasticities are misspecified and discretionary shocks not precisely identified. Figure 4 shows the regression result and the scatter-plot of the output gap on the x-axis and the adjusted growth rates of revenues on the y-axis. We detect no correlation between the two series, which speaks in favour of the elasticity applied and indicates that non-linearity is more likely to be rooted in discretionary fiscal policy reactions than in automatic stabilisers.

The identification of b_1 is easier. It can be set to zero, as the main component of primary government spending (unemployment transfers) is included in net revenues.

II) In the second step, we construct the contemporaneous influence of revenues and expenditure on GDP, c_1 and c_2. With the estimates of a_1 and b_1 the cyclically adjusted reduced-form fiscal policy shocks (revenue and spending residuals) are calculated with $t'_t = t_t - a_1 gdp_t$ and $g'_t = g_t - b_1 gdp_t = g_t$. These can be used as instrument variables in the third equation of system (16). They are considered as instruments since they are no longer correlated with ε_t^{GDP} (though still correlated with each other). Therefore, we can consistently estimate the coefficients c_1 and c_2 with least squares estimation.

III) In the final step, the remaining parameters a_2 and b_2 need to be determined. In the literature it is controversially discussed whether taxation follows spending ($b_2 = 0$) or spending follows taxation ($a_2 = 0$) (see e.g. Kollias and Paleologou 2006, Hoover and Sheffrin 1992 or Koren and Stiassny 1998). In the baseline model, a_2 is constrained to zero and b_2 is estimated (revenue decisions come first).

The time-varying elasticity of a_1 with a mean around one and the described identification yield the following matrices of contemporaneous relationships R_{lin}, and R_{nonlin} for the linear and non-linear model:[29]

$$R_{lin} = \begin{pmatrix} 1 & 0 & 1.0119 \\ 0.0840 & 1 & 0 \\ -0.2070 & 0.2744 & 1 \end{pmatrix} \quad R_{nonlin} = \begin{pmatrix} 1 & 0 & 1.0119 \\ 0.0964 & 1 & 0 \\ -0.1881 & 0.2293 & 1 \end{pmatrix}. \tag{23}$$

We see large differences between the non-linear and the linear model. For example, the contemporaneous influence of revenue and spending shocks on

[29] As a simplification (and to save space) the resulting $\overline{A}$ and B matrices will be presented combined and are given in all following sections in the form

$$R_{lin} = \begin{pmatrix} 1 & 0 & a_1 \\ b_2 & 1 & 0 \\ c_1 & c_2 & 1 \end{pmatrix}.$$

unexpected changes in GDP (lower left and middle entry) are substantially smaller in the non-linear case.

5.4 Impulse Response Analysis

In the following subsections we will present and discuss our estimation results based on impulse response functions (IRF). We start with the linear benchmark model and then discuss the IRFs for fiscal shocks in the lower and the upper regime of the threshold model. Throughout the GIRF generation, we update the output gap after each forecasted quarter using a one-sided HP-filter. Additionally we review the effects of an increase in the size of shocks and the dependence of the results on the definition of the threshold variable (the GDP growth rate series is used as an alternative).

5.4.1 Linear Impulse Response

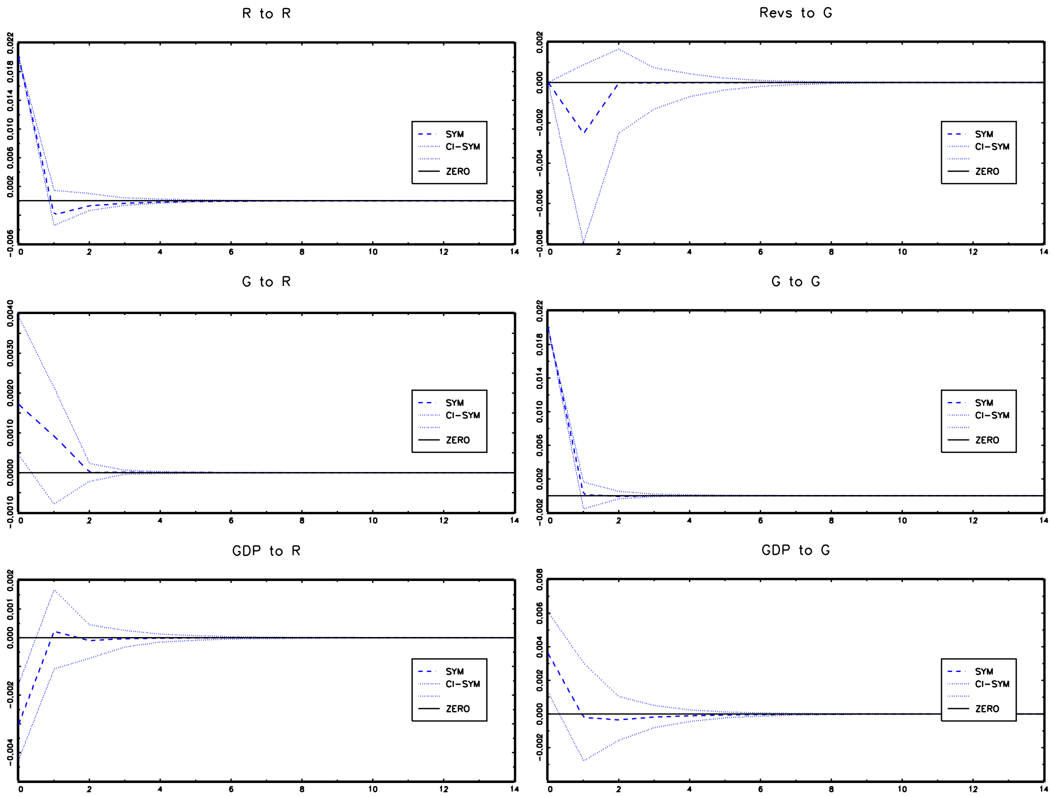
The linear impulse responses for a one-time shock in revenues and spending are presented in figure 5. Since the purpose of this paper is to analyse the impact of fiscal policy on GDP (not vice versa), we do not show the impulse responses to a shock in GDP. As a benchmark we apply a shock of 2%.

We find that government spending reacts weakly but positively to a revenue shock, with an IRF that returns to zero within two periods. Since we have set the contemporaneous reaction of revenue to a public spending shock to zero (see section 5.3), revenues react with a lag of one period. The response is negative for this period and zero thereafter.

The lower two figures show the response of GDP growth. The impact of revenue increases on GDP is small and negative, with a contemporaneous effect of -0.3%. The positive spending shock has a small positive impact on GDP, with a contemporaneous value that is slightly larger than the absolute value for revenue changes, and a cumulative effect of about 0.35% after three quarters. Taking into account that, over the observation period, government spending and revenues equal on average 41% and 39% of GDP, respectively, we obtain a fiscal spending multiplier of 0.7 and a revenue multiplier of -0.66 (all multiplier results are presented in table 5). The fiscal multipliers for expenditure and revenue policies are of similar size and are generally moderate - meaning that a stimulus of 1% of GDP increases GDP in the short run by substantially less than 1%. This would indicate that public spending causes a partial crowding out of private activity - a result in line with the findings of comparable SVAR studies using the Blanchard-Perotti identification.

In the following we present the GIRFs. In order to directly compare positive and negative shocks, the linear IRFs are included and the negative impulse responses are shown mirror inverted.

Figure 5: Linear Impulse Responses, Shocks in R and G



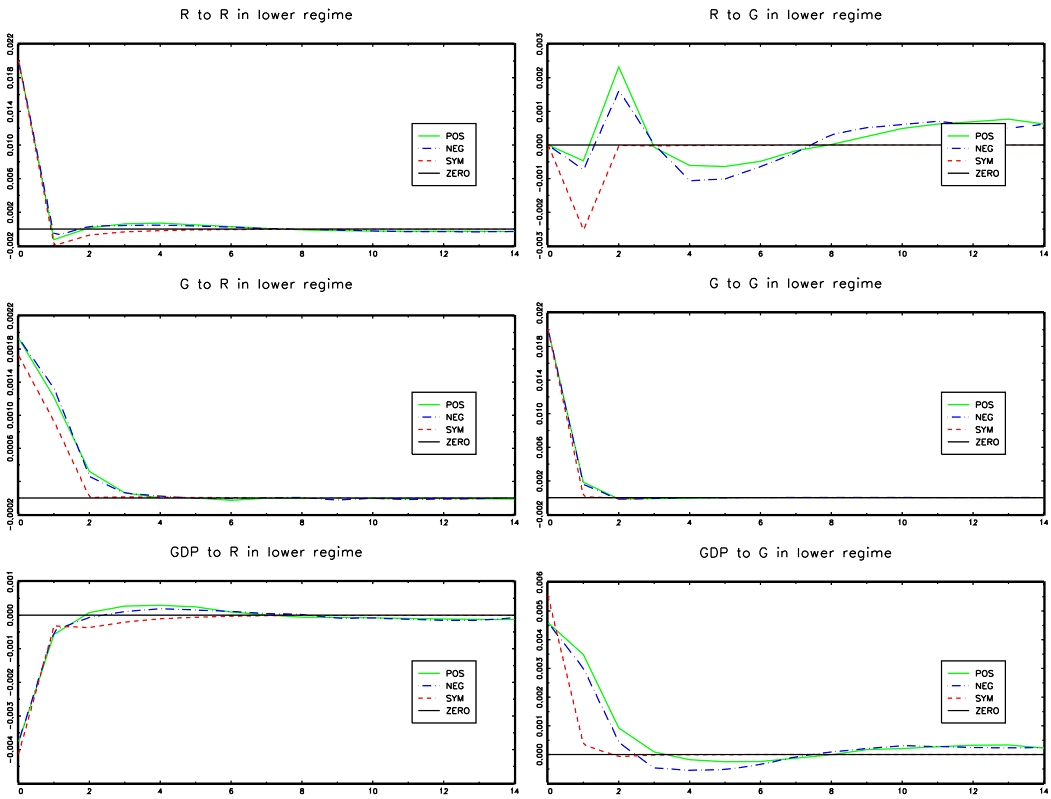
5.4.2 Lower Regime, 2% Growth Shock

The GIRFs for a 2% fiscal shock are shown in figure 6. The red (evenly dotted) IRs represent the linear model, while the solid and variable-dotted lines show the responses to positive and negative shocks, respectively. Foremost, we find clear differences between the lower output gap regime and the linear model, especially in response to spending shocks. As such, the GIRF for a spending shock on revenues is negative after one period, but becomes positive for the second quarter after a shock and again negative after the fourth quarter.

The lower right figure reveals that the GDP response to a fiscal spending shock in periods of negative output gaps is larger and more persistent than the linear model suggests. Although we find a lower contemporaneous influence of spending on GDP than in the linear identification (compare system 23), the cumulative response is larger and more persistent. In specific, the fiscal multiplier increases to 1.04 four quarters after the shock and is still 0.99 ten quarters after the shock (see table 5). Thus, with almost no crowding-out in the long run, the spending multiplier slightly above unity indicates the possibility for fiscal policy to stimulate unused factors of production. The result further implies that the linear model underestimates especially the short-run impact of government spending activity under negative output gaps.

Comparing this result to the revenue multipliers, we find only a small

Figure 6: Lower Regime: 2% Growth Shock



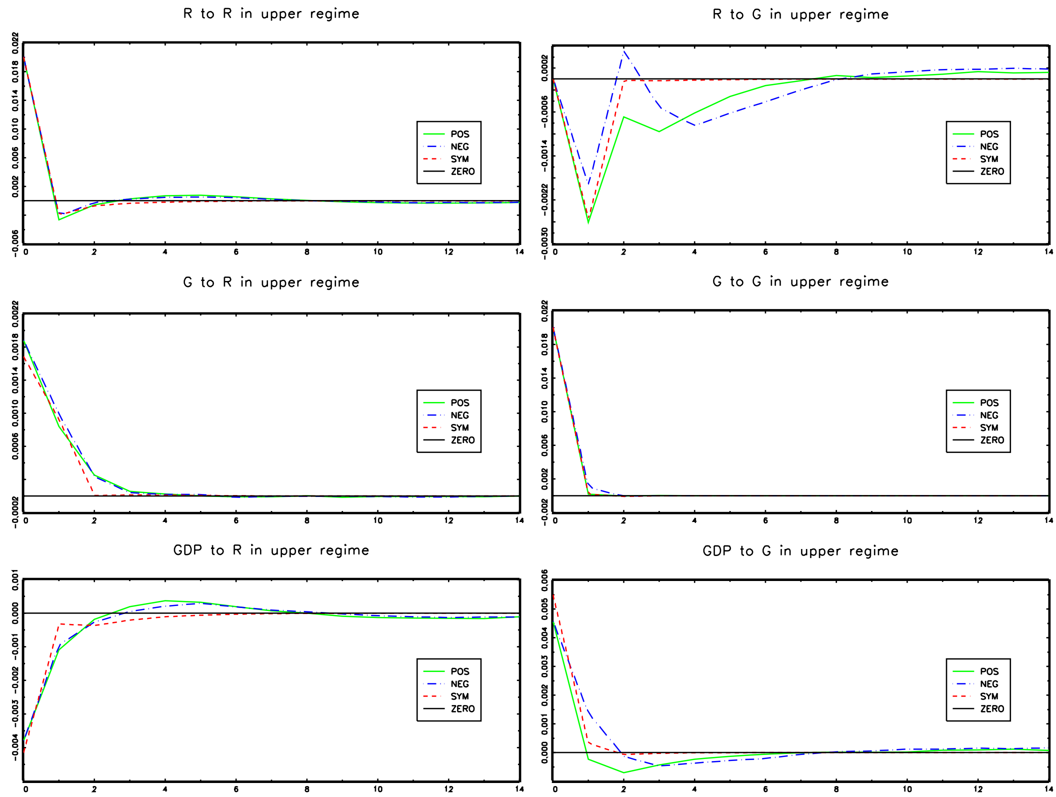
difference between the linear and non-linear model. The cumulative short-run revenue multiplier decreases to 0.5 in absolute terms, compared to 0.66 in the linear model, indicating that tax reductions do appear to be less well-suited to pushing the German economy out of a recession than expenditure increases. On the other hand, tax increases in a period of a negative output gap do seem to harm the economy especially in the short-run less than expenditure cuts.

Figure 6 further shows that differences between the positive and negative GIRFs are relatively small, with the reason being that the output gap responds only sluggishly to economic growth. As an example, assume that in the lower regime a positive spending shock on GDP pushes the economy into the upper regime, while a negative shock does not. With different parameter estimates for the two regimes we would expect different responses. But since the output gap is very persistent, a regime change does not occur frequently at a small shock size and the positive and negative responses can be very similar.

5.4.3 Upper Regime, 2% Growth Shock

For the upper regime - reflecting the periods when the economy is above potential output - the GIRFs for a 2% growth shock are shown in figure 7. While the responses to revenue shocks are again close to the linear model IRFs (and the lower regime), the GIRF of revenues to a positive spending

Figure 7: Upper Regime: 2% Growth Shock



shock is now negative for at least eight quarters following the shock.

The most striking difference to the lower regime is the response of GDP to a spending shock. The contemporaneous response is small and it becomes negative from the first quarter following the shock. As a consequence, the fiscal multiplier, at 0.36 after four quarters, is substantially lower than in the linear model and the lower regime values. This smaller multiplier indicates a substantial crowding-out of private activity, even in the short-run. Thus, our model suggests that governments should refrain from expansionary fiscal policy through spending increases in periods where a positive output gap prevails.

The upper regime revenue multipliers are comparable to the lower regime, with -0.58 and -0.53 after four and ten quarters, respectively. Based on the observations that spending multipliers in the upper regime are substantially smaller than the lower regime ones, with an included and large crowding out effect, it seems more effective to employ spending policies only under a negative output gap regime, and limit tax policies to the times when output is above its potential.

5.4.4 Comparison Lower and Upper Regime, Increasing Shock Size

In general, the size of the shock can lead to noticeable differences in the responses of the GIRFs, even with the sluggishness of the output gap. Figures

Table 5: Fiscal Multipliers

4-Quarter								
	spending shock				revenue shock			
Size	2%		5%		2%		5%	
Sign	pos	neg	pos	neg	pos	neg	pos	neg
Linear model	0.7				-0.66			
Lower regime	1.04	-0.86	1.27	-0.84	-0.5	0.51	-0.48	0.53
Upper regime	0.36	-0.60	0.26	-0.84	-0.58	0.61	-0.60	0.62
10 Quarter								
	spending shock				revenue shock			
Size	2%		5%		2%		5%	
Sign	pos	neg	pos	neg	pos	neg	pos	neg
Linear model	0.69				-0.68			
Lower regime	0.99	-0.84	1.28	-0.83	-0.49	0.49	-0.47	0.51
Upper regime	0.34	-0.56	0.28	-0.75	-0.53	0.54	-0.54	0.57

Calculated based on ratio of spending and revenue to GDP.

8 and 9 show that, while the responses of revenue shocks are almost identical to the small shock size results, especially the upper regime GIRFs following expenditure shocks change noticeably, with increased differences between positive and negative responses. Accordingly, the fiscal spending and revenue multipliers provided in table 5 change substantially only for larger expenditure shocks: The short term multiplier of a 5% spending increase is 1.27 in the lower but only 0.26 in the upper regime. Spending reductions of 5% have in both regimes a short-term multiplier of -0.84.

6 Robustness Checks

To make sure that our results are robust and reliable, we test the influence of the application of an alternative threshold variable, of alternative structural identification schemes, variations in the exogenous elasticity, the data sample and the threshold value.

6.1 GDP Growth Threshold

An alternative threshold variable is GDP growth. By using growth rates we analyse how the effect of fiscal shocks differs if GDP growth is below or above a certain threshold rate. Since GDP growth is relatively volatile, the threshold series is defined as the three-quarter moving average of the series. Furthermore, in order to account for economic rigidities the threshold series follows the variables with one lag. The Tsay test rejects linearity and we obtain a threshold value of 0.0035 (real GDP growth of 0.35%), spitting the sample into 54 observations in the lower, and 82 observations in the upper growth regime. The responses for a 2% growth shock are presented in figures 10 and 11.

In general, most of the responses change moderately, with the clearest changes observed in the responses of the fiscal variables to one another. However, the implications we derived in the baseline specification do not change significantly. The linear model underestimates the fiscal spending multipliers in the lower, and overestimates them in the upper regime, even though this effect is smaller with GDP growth as the threshold variable. The results for a revenue shock on GDP do not show drastic changes, although the revenue multiplier in the upper regime is somewhat smaller than the lower regime value. Thus, using a different measure for economic performance as threshold variable has almost no impact on the estimation.

6.2 Structural Identification

We employ different (fixed) values for a_1 in the structural identification, accounting for diverging values in the literature. In the identification of section 5.3, we allowed the elasticity to be time-varying for a less biased structural identification, with a mean of a_1 to be around 1, whereas values in the empirical literature range from 0.46 as in Bode et al. (2006) to above one as in Höppner (2001) and Leibfritz (1999). In order to rule out any impact of the specific value of the calculated elasticity on the implications, the IRFs are estimated for two alternative elasticities, 0.5 and 1.5. Figures 12 and 13 show the resulting linear IRFs and GIRFs. The only noticeable difference to the benchmark model is the magnitude of the response of GDP to a revenue shock, which increases (decreases) substantially in size for an elasticity of 0.5 (1.5) for both the linear and non-linear model. At any rate neither the implications for the threshold model in response to a revenue shock, nor those for the model in response to a spending shock change with different elasticities; we can therefore conclude that the model is robust to changes in a_1.

In a second robustness check we apply the Cholesky decomposition in order to determine the extent to which the identification approach matters. We compare the IRFs for the alternative variable orders $GDP \rightarrow R \rightarrow G$ and $R \rightarrow G \rightarrow GDP$, shown in figures 14 and 15 for the lower growth regime (including the linear model), in figures 16 and 17 for the upper regime (and a shock size of 2 SE, which roughly corresponds to a 2% revenue and 1.5% expenditure shock). For both impulse orders the results of the GDP responses change drastically, especially in the linear model (the responses in the fiscal variables are only mildly affected). In the linear model, for both impulse orders, the response of GDP to a revenue shock is positive, albeit small. This result is very close to the one found by Afonso and Sousa (2009), who also apply a Cholesky identification. The linear IR of GDP to a spending shock is very sensitive to the change in the impulse order. Being entirely negative for $GDP \rightarrow R \rightarrow G$, it accumulates to a positive multiplier for $R \rightarrow G \rightarrow GDP$. On the other hand, the threshold specification shows that the response of GDP to a spending shock is robust in the impulse ordering (although we find the same positive impact of a revenue shock). In the lower regime, the spending multipliers are similar to those obtained with the Blanchard and Perotti identification. In the upper regime multipliers do not change significantly for the order $R \rightarrow G \rightarrow GDP$, but decrease drastically for the alternative. However, in both cases, the upper regime responses yield significantly smaller fiscal spending multipliers than the lower regime.

This analysis leads to two conclusions. First, the exact structural identification is of great importance, for the non-linear model but even more for the linear specification. Since the Blanchard and Perotti (2002) identification approach focuses mainly on the interaction between revenues and GDP, it is not surprising that the Cholesky decomposition changes the GDP response to a revenue shock in the linear and the non-linear model (and for both variable orderings). Second, we see that the threshold model is more robust to changes in the identification strategy than the linear model. The comparison of the two regimes provides more room for interpretation than the volatility-prone linear model allows. That is, the implications from the non-linear estimation remain very similar. In the lower regime, we observe higher absolute fiscal spending and revenue multipliers, in the upper regime they are comparably lower.

In summary, the identification approach does not substantially influence the non-linear reactions to a spending shock. However, changes in a_1 as well as the overall identification framework have major implications for the GDP response to revenues. Thus, the exact identification in a structural model is important. In our view, the PB identification is preferable to a Cholesky ordering, as it is better suited for distinguishing between the working of automatic stabilisers and discretionary fiscal policy.

6.3 Data Sample and Threshold Value

As the observations of 2009 and the end of 2008 are strongly affected by the financial crises, we first re-estimate the model excluding the last 5 periods of the data sample. The results for the threshold tests do not change significantly and are therefore not shown. Furthermore, the shorter data sample yields a similar threshold estimate of around -0.0015. Figure 18 and 19 show the responses in the upper and lower growth regime for a shock of 2%. We can find the main changes in the lower regime upper right graph, with the responses of revenues in the first two quarters being entirely positive. That the main changes occur in the lower regime is not surprising as the output gap in 2009 was negative and therefore the last five observations are covered by the lower regime. The changes indicate that the effect of spending on revenues was especially strong in the year 2008/2009.

We also re-estimate the model excluding the first four years of the sample, starting in 1980 in order to analyse the influence of the persistently high GDP growth rates between 1976 and 1980. Since none of the responses shows any noticeably changes (in neither lower nor upper regime) they are not shown here.

Furthermore, we conduct the analysis with a higher threshold value to account for potential inaccuracy in the threshold estimation (although the Tsay test results are similar for the three different lag specifications). We employ a threshold value of zero, which increases the lower regime observations to 74. The results for the new GIRFs, shown in figure 20 and 21, reveal that only the upper regime responses change substantially. Government spending as well as GDP show clear differences in the reactions to positive and negative revenue shocks, and the positive as well as the negative fiscal spending multipliers are significantly below zero. Since the lower regime responses do not change significantly, we can conclude that observations corresponding to a "possible middle regime" do not influence the lower regime, but they lead to a moderation of the responses in the upper regime.

7 Conclusions

What are the effects of discretionary fiscal policy shocks? And do they differ over the different phases of the business cycle? In this paper we extend the existing VAR literature on German fiscal policy shocks by a non-linear threshold component, using the output gap as a threshold variable and thereby dividing the time period from 1976-2009 into a positive and a negative output gap regime.

In a first step we estimate a linear benchmark model for which we derive fiscal multipliers of around 0.7 (absolute value) for revenue and expenditure policies, indicating moderate expansionary effects of revenue cuts and expenditure increases. These values are supported by the literature, although some studies derive inverted revenue effects. Those response differences could result from diversity in how that data are defined. As such, our revenue series includes security contributions which are often omitted in the literature (such as Heppke-Falk et al. 2010). Thus it remains to be seen if we would face similar problems based on a narrower data definition excluding social security.

As the Tsay (1998) test indicates the necessity of a non-linear model, we estimate a threshold VAR for a lower (negative output gap) and an upper (positive output gap) regime. Based on this model we obtain general impulse response functions that clearly differ between the lower and the upper regime (and deviate from the linear responses). These deviations have important implications. In periods of a negative output gap, the short-term fiscal spending multiplier of a positive shock is around unity - indicating a comparatively high effectivity of economic stimulation via public spending. In contrast, the short-term spending multiplier for a positive shock found during "good times" (positive output gap) is with 0.36 very small, indicating a strong crowding-out of an expenditure stimulus in booms. The effects of negative spending shocks differ in both regimes less strongly from the results of the linear model. With increasing shock size the differences between positive and negative spending multipliers and between upper and lower regime increase strongly: The short term multiplier of a 5% spending increase is 1.27 in the lower but only 0.26 in the upper regime. Spending reductions of 5% have in both regimes a short-term multiplier of -0.84. This underlines that the assumption of a linear influence of fiscal spending on the economy with a multiplier of around 0.7 can give misleading policy implications. As such, when the output gap is above a certain threshold, especially expenditure increases could well be less effective than current linear studies indicate, while our analysis suggests that they are significantly more effective in times of a negative output gap. Furthermore our results show that the differences between positive and negative shocks in both regimes increase with the size of the shocks, which further strengthens the effects described.

With respect to revenue shocks we find less diverging results than on the expenditure side. Revenue changes have generally only a limited effect on GDP with short-term multipliers between 0.48 and 0.62, which differ only slightly from the multiplier of 0.66 in the linear model. This implies that economic stimulation in times of negative output gaps works less well via revenue cuts than via expenditure increases, while the opposite holds for the upper regime.

None of our conclusions changes if we apply a three-quarter moving average of GDP growth instead of the GDP gap as threshold variable. Further robustness checks show that our general implications are not vulnerable to reasonable changes of the elasticity or the overall structural identification scheme, the time period analysed or small deviations in the threshold value. The non-linear threshold analysis shows far more robust behaviour than the linear analysis, even if the GDP response to revenue shocks is relatively volatile. Specifically, the response differences between the upper and lower output gap regime following a spending shock remain statistically significant. However, our robustness results re-emphasise the importance of a profoundly deliberated structural identification.

In summary, our analysis suggests that fiscal steering of the economy via revenue policies should only (if at all) be pursued in times of a positive output gap, while discretionary spending measures to boost the economy have a comparably larger impact in times of a negative gap and should be concentrated here. However, our results shall not be interpreted as clear policy advice, they should rather be understood as indicating gradual differences in the impact of fiscal policy depending on the state of the business cycle.

A GIRF Algorithm

Assuming that the non-linear model is known, the GIRF for a given regime with R observations can be calculated with the following algorithm:

1. Pick a history Ω^r_{t-1}, with $r = 1, ..., R$ referring to an actual value of the lagged endogenous variable at a particular date r. Note that R refers to the values corresponding to the regime the impulse responses are calculated for. Thus, the same algorithm has to be conducted twice, for the lower and again for the upper regime.

2. Pick sequences of shocks ε^*_{t+m}. These are generated by taking bootstrap samples from the estimated residuals ε_t of the TVAR.

3. With the information set Ω^r_{t-1}, the estimated coefficients of the TVAR and the structural errors ε^*_{t+m}, simulate the evolution of y over m periods. The resulting baseline path is given by $y_{t+m}(\Omega^r_{t-1}|\varepsilon^*_{t+m})$.

4. Modify the path of y by adding a shock ε_0 to the first residual of the randomly drawn errors. Again simulate the evolution of y over m periods. The resulting (shocked) path is given by $y_{t+m}(\Omega^r_{t-1}|\varepsilon_0, \varepsilon^*_{t+m})$.

5. Repeat steps 2 to 4 B times to get B estimates of the baseline and the shocked path.

6. Take the average over the difference of the B estimates of the two paths. This gives an estimate of the expectation y for a given history Ω^r_{t-1}.

7. Repeat steps 1 to 6 over all possible histories, that is, the number of observations R for the regime the GIRF is calculated for.

8. Finally compute the average GIRF for a given regime with R observations as

$$y_{t+m}(\varepsilon_0) = \frac{1}{R}\sum_{r=1}^{R} \frac{y_{t+m}(\Omega^r_{t-1}|\varepsilon_0, \varepsilon^*_{t+m}) - y_{t+m}(\Omega^r_{t-1}|\varepsilon^*_{t+m})}{B}. \qquad (24)$$

With this algorithm, we obtain the GIRFs based on the regime-specific coefficients and contemporaneous coefficient matrices resulting from equation (31).

steps:

Table 6: Calculated Elasticities

	Elasticity with respect to real GDP	Average share in revenues 1970-2008	Weighted elasticity
Direct taxes (households and corporations)	1.57	0.27	0.43
Indirect taxes	1	0.27	0.27
Social contributions	0.57	0.42	0.24
Other revenues	0	0.04	0
Elasticity revenues	0		**0.94**
Unemployment spending	-1.4	0.06	-0.08
Elasticity net revenues			**1.02**

B Exogenous Elasticities

In the literature we find several methods of calculating exogenous revenue and expenditure elasticities. For example, Heppke-Falk et al. (2010) derive the exogenous elasticity based on highly disaggregated time series data, applying the elasticities calculated by Mohr (2001) and Kremer et al. (2006). We follow the alternative "standard" OECD approach (applied by Girouard and André 2005, van den Noord 2000, Giorno et al. 1995 and in his fiscal policy analysis by Perotti 2004). It comprises a two-step procedure: first, to calculate the elasticity of the different tax bases and of unemployment with respect to GDP and then to apply an exogenous elasticity for the reaction of tax revenues to tax bases and of unemployment spending to unemployment is applied.

The components of the "net revenues" that are contemporaneously affected by changes in GDP are direct taxes, indirect taxes, social contributions and unemployment related spending. Based on the elasticities calculated by the OECD (see Girouard and André 2005) we use a direct tax elasticity of 1.57. This high elasticity results from the progressive income taxes and the strong cyclical behavior of corporate profits.[30] Most indirect taxes are levied by proportional rates and have an elasticity of 1. Social contributions increase less strongly than GDP mainly because they are levied only up to a certain income threshold (which varies depending on the social insurance) and because the wages as their base react less strongly to GDP than taxable income. The elasticity of social security contributions in Germany (based on the OECD estimates) is 0.57. If we weigh the individual elasticities pro-rata overall revenues, the weighed GDP elasticity is on average 0.94.

In contrast to tax revenue, unemployment reacts mirror-inverted to GDP fluctuations and decreases when GDP increases. In the literature we find a wide

[30] The OECD calculates an elasticity of 1.61 for corporate income taxes and 1.53 for personal income taxes. Because of a methodological break between ESA 1979 and 1995, there is no consistent separate series for corporate and personal income taxes in our dataset. Therefore we apply the mean of the two elasticities to all revenue from direct taxes.

Table 7: Elasticities in the literature

	Elasticity with respect to real GDP	**Period**	**Data definition**	
Perotti (2004)	0.92	1960-89	net revenues =	government revenues - transfers - interest
Perotti (2004)	0.91	1960-74	net revenues =	government revenues - transfers - interest
Perotti (2004)	0.72	1975-89	net revenues =	government revenues - transfers - interest
Höppner (2001)	1.04	1970-2000	direct and indirect taxes	
Bode et al.(2006)	0.46	1991-2005	taxes and social security contributions	- transfers
Heppke-Falk et al. (2010)	0.95	1970-2004	net revenue =	government revenues - transfers - interest
Baum/Koester (2010)	1.01	1976-2009	net revenue =	government and social security revenues - unemployment expenditure - interest

variation in estimates on the reaction of unemployment to GDP fluctuations in Germany, which range between -5 (Girouard and André 2005) and -0.8 (van den Noord 2000). Based on the German dataset from 1976-2009, we calculate an elasticity of -1.4. Combining the ratio of unemployment spending over total revenues (5.7%) with the elasticity of -1.4 and subtracting the resulting value from the overall revenue elasticity increases the overall net revenue elasticity to 1.02. Thus, a 1% increase of GDP increases net revenues by around 1%. Table 6 summarises the calculation including the average shares of the net revenue components. To account for the variation of the revenue shares over time, we use a time-varying elasticity in the structural identification. Instead of the displayed elasticities calculated based on the average share of the components over the whole sample, the quarterly elasticities are calculated based on the share of the components in each respective quarter.

For comparison, table 7 provides elasticities calculated in other German fiscal policy studies. The lowest value, at 0.46, is very small (Bode et al. (2006) using German data covering 1991 to 2005), which results from a lower effect of GDP on wage growth than the OECD method suggests. Most of the other papers derive an elasticity that is close to unity (for net revenues). Including only direct and indirect taxes, the largest elasticity is calculated to be 1.04 (Höppner 2001). Simulation studies for Germany are another point reference. The values for the effects of automatic stabilisers, derived for instance by Toedter and Scharnagl (2004) based on the Bundesbank model, indicate elasticities which would be closer to 0.5 than to 1. However, these low values are covered by our robustness tests, which apply an elasticity of 0.5.

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Figure 8: Lower Regime: $a_1 = 0.5$, 2% Growth Shock

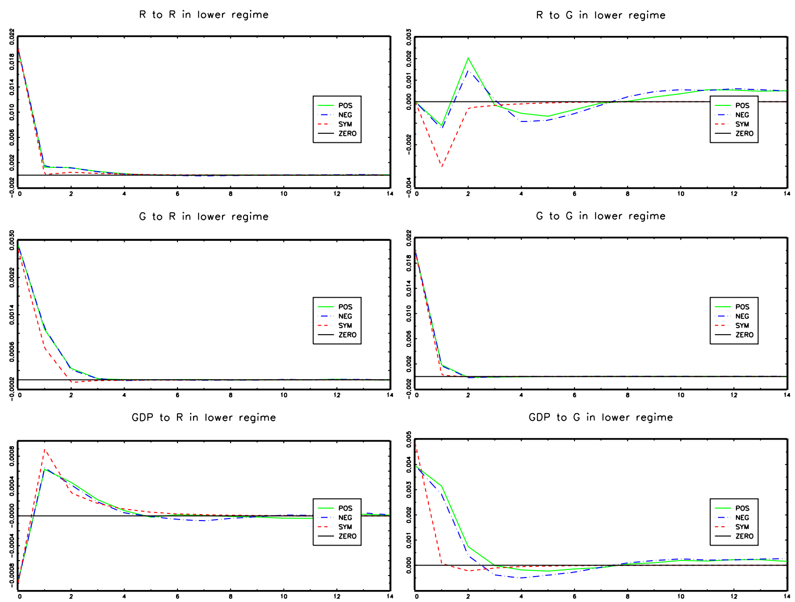


Figure 9: Lower Regime: $a_1 = 1.5$, 2% Growth Shock

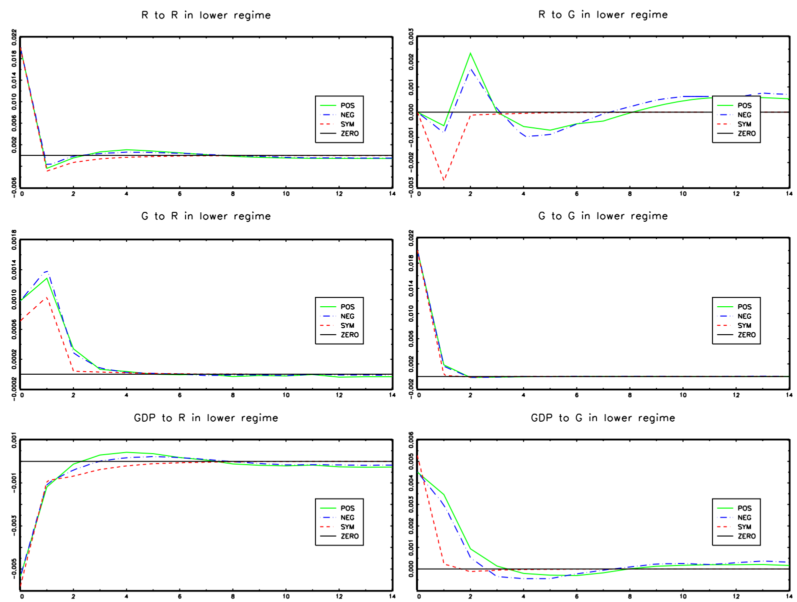


Figure 10: Lower Regime: 1976-2008

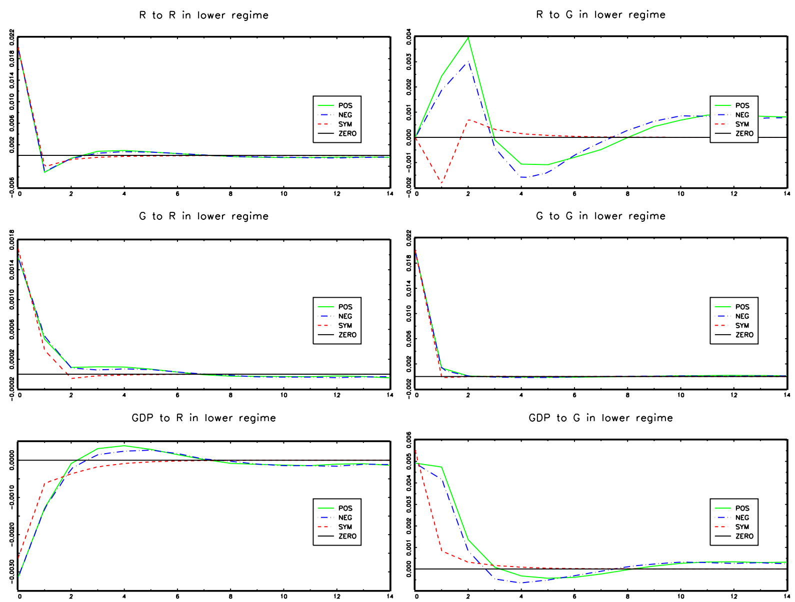


Figure 11: Upper Regime: 1976-2008

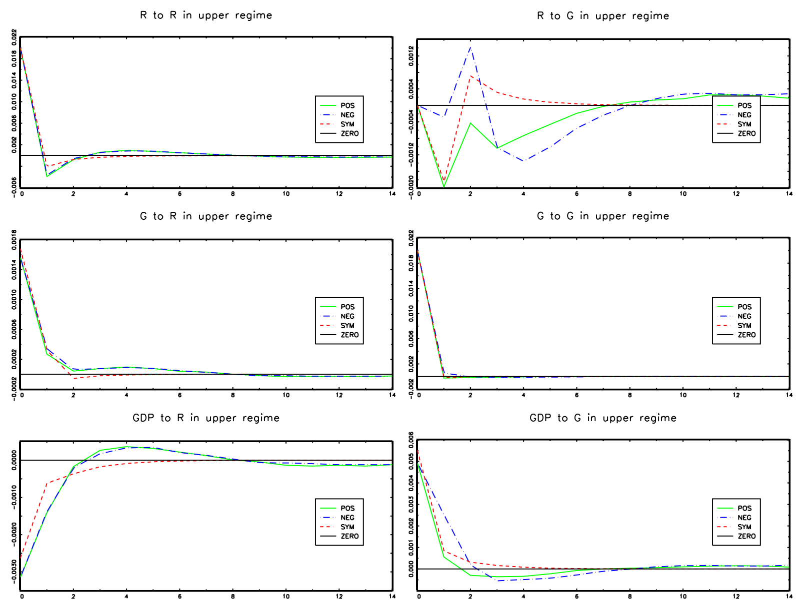


Figure 12: 5% Growth Shock - Lower Regime

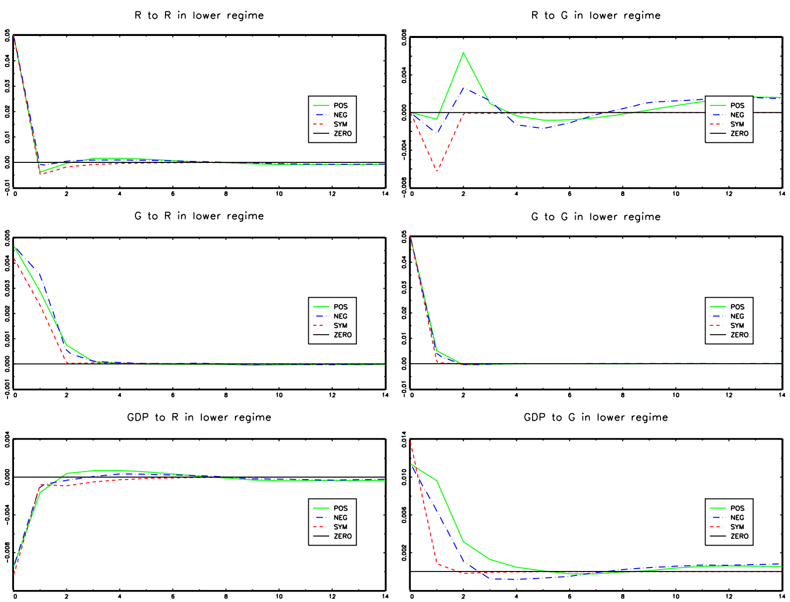


Figure 13: 5% Growth Shock - Upper Regime

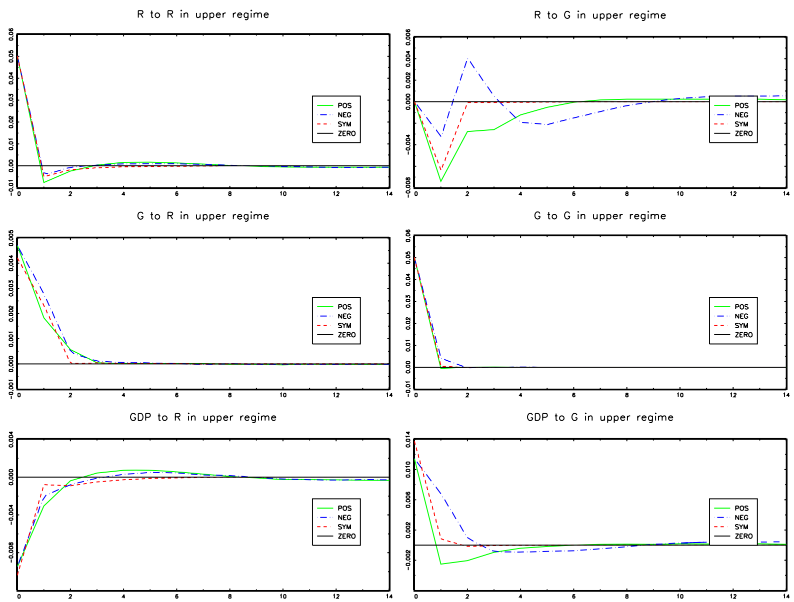


Figure 14: IR for GDP Growth as Threshold: 2% Growth Shock - Lower Regime

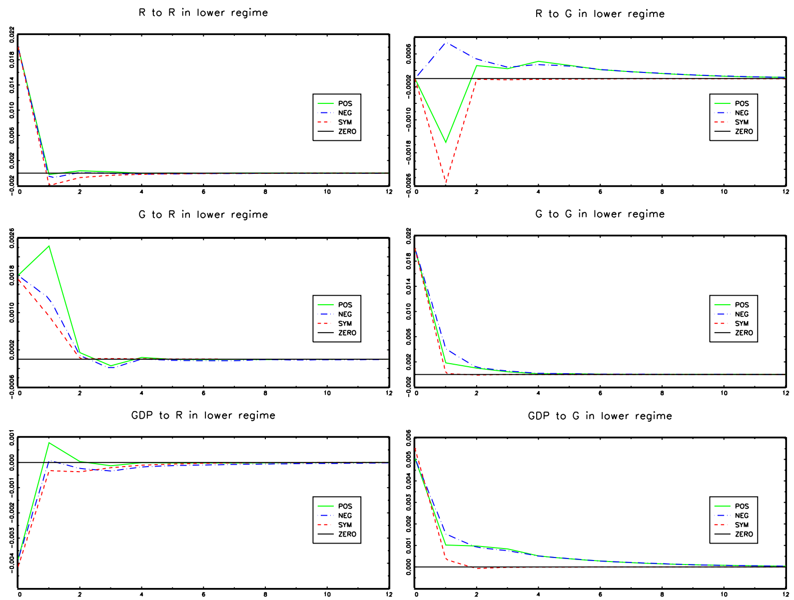


Figure 15: IR for GDP Growth as Threshold: 2% Growth Shock - Upper Regime

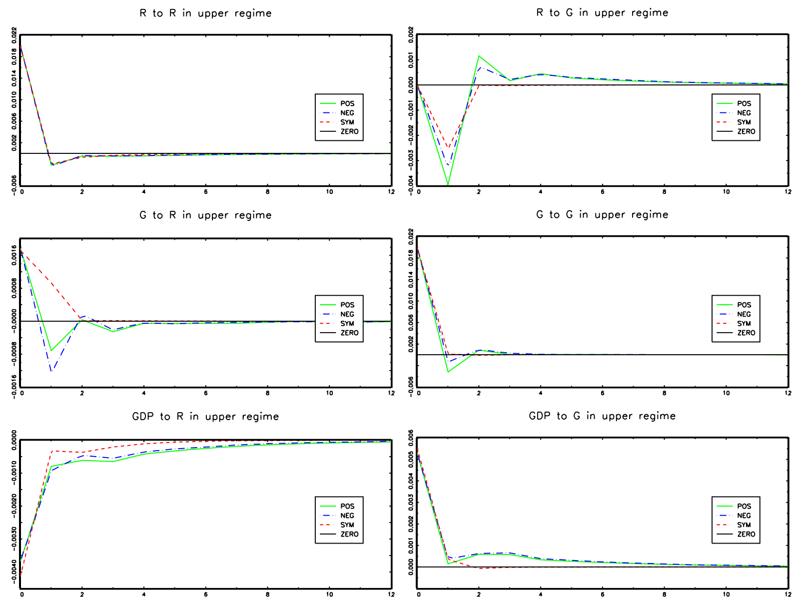


Figure 16: Lower Regime: Threshold of Zero - 2% Growth Shock

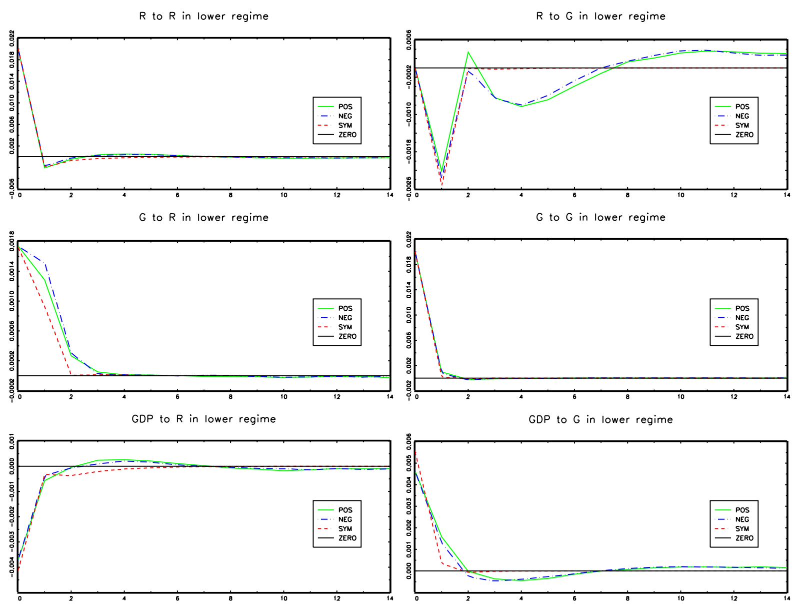


Figure 17: Upper Regime: Threshold of Zero - 2% Growth Shock

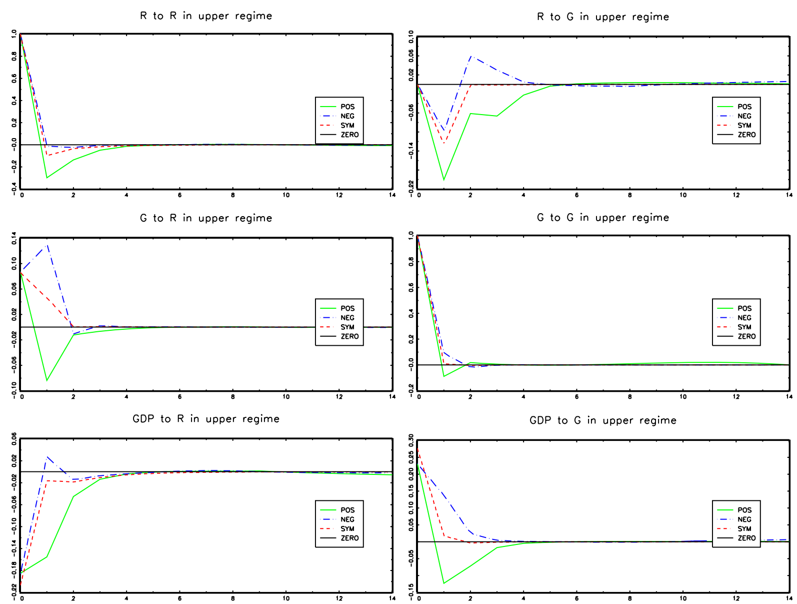


Figure 18: Lower Regime: Cholesky Order GDP → R → G

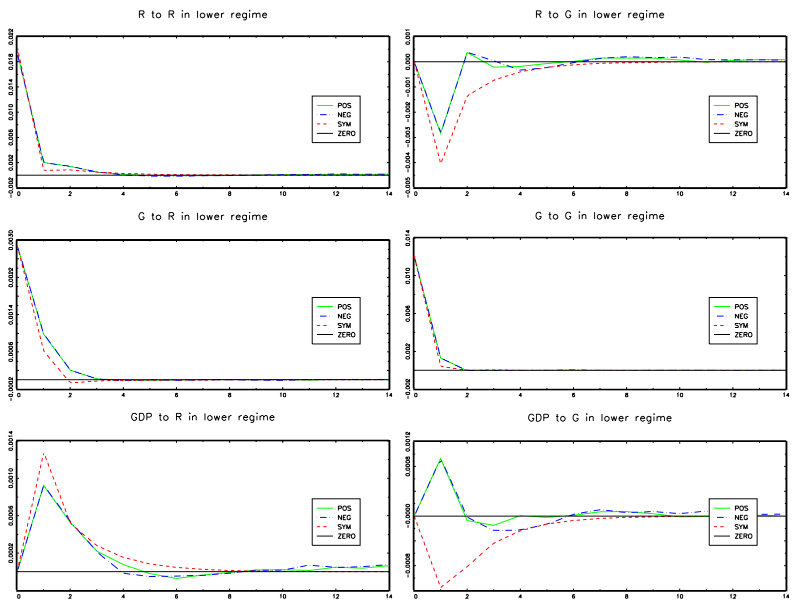


Figure 19: Lower Regime: Cholesky Order R → G → GDP

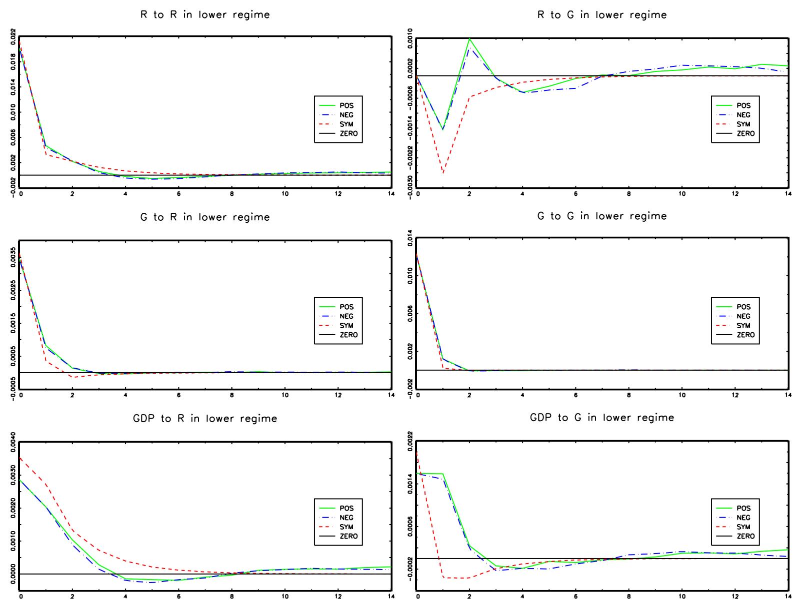


Figure 20: Upper Regime: Cholesky Order GDP → R → G

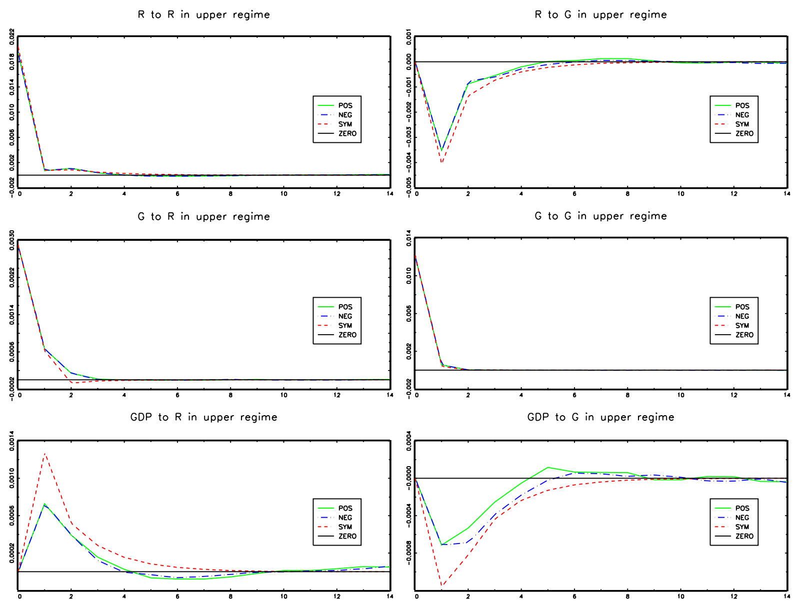
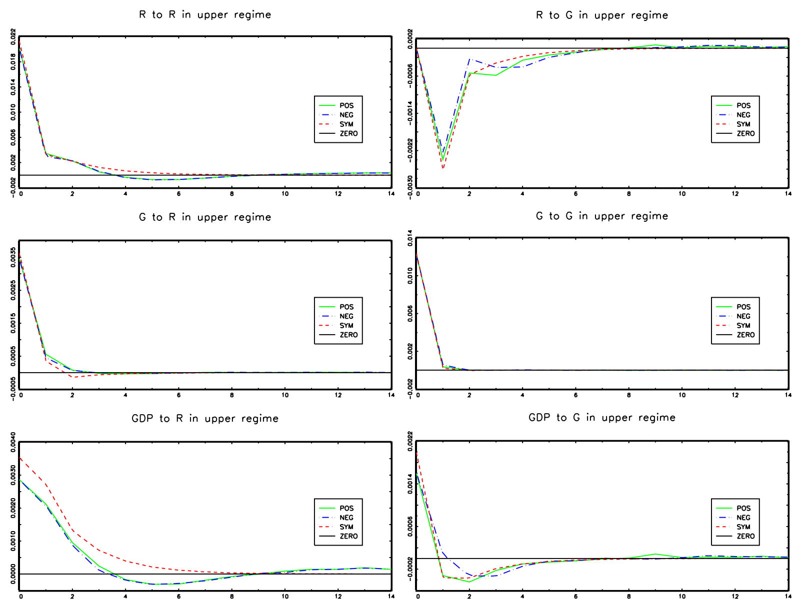


Figure 21: Upper Regime: Cholesky Order R → G → GDP



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