Changing Patterns of Fiscal Policy Multipliers in Germany, the U.K. and the U.S.

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Abstract

This paper documents time variation in fiscal policy multipliers in Germany, the UK and the US over the period 1971-2009. The analysis is based on a quarterly vector autoregression (VAR) model. For the German and the UK case, the VAR is augmented by "global factors" representing developments in the world economy. By estimating these models on different samples of data, our evidence indicates that fiscal multipliers have substantially changed over time, often in a non-monotonic way. In particular, for Germany, the net tax multiplier is found to follow a humped-shaped curve, peaking in the middle of the 1990s, declining thereafter, before rising again during the recent 2008-09 crisis. Government spending shocks are found to be more powerful to stimulate output after the reunification. We show that significant crowding-in effects for private investments contribute to explain this finding. For the UK, we observe large variations in fiscal multipliers over the period, with non-Keynesian developments during the fiscal consolidation period of the 1980s. After that, British multipliers are low and only pick up at the very end of the sample, when the 2008-09 crisis is included in the analysis. For the US, short-run multipliers appear to be broadly stable over the period, but medium-run multipliers tend to decline, in particular in the end of the 1980s and in the 1990s. This can be due to the large fiscal imbalances over this period that may have triggered Ricardian effects, before a fiscal surplus was achieved at the end of the 1990s.

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1 Introduction

The use of fiscal policy as a stabilizing tool regained attention in the context of the 2008-2009 financial and economic crisis, when many governments adopted large stimulus packages. For instance, in the European Union, the fiscal stimulus adopted within the European Economic Recovery Plan (EERP) amounted to around 2% of the EU's GDP cumulatively over the period 2009-2010. The fiscal stimulus was even larger in the US, where measures contained in the American Recovery and Reinvestment Act of 2009 amounted to around 5% of GDP in the years 2009-2011 (see European Commission (2009)). Yet, there is no consensus in the literature on whether fiscal policy is an effective tool to counteract recessions and, in general, to dampen economic fluctuations.

Two classes of models have been typically used to study the effects of fiscal policy shocks. On the one hand, estimated or calibrated dynamic stochastic general equilibrium (DSGE) models (see e.g. Giudice, Turrini and in't Veld (2004), Coenen and Straub (2005), Galì, López-Salido and Vallés (2006)). On the other hand, vector autoregression (VAR) models, where fiscal shocks are identified through alternative techniques (see Blanchard and Perotti (2002), Perotti (2005), Beetsma, Giuliodori and Klaassen (2006), Mountford and Uhlig (2009), Ramey (2009)). The main advantage of the former class of models is that structural interrelations among economic variables are modeled explicitly. However, results depend heavily on built-in assumptions. VAR models, in turn, are less dependent on theoretical assumptions, but they provide weaker economic interpretations.

The recent paper by Coenen et al. (2010) provides a literature review on VAR studies, and a comparison of estimates from seven structural models from central banks and international institutions.[1] It is concluded that, in the short run, fiscal policies tend to have Keynesian effects: a fiscal expansion leads to a rise in national output, in particular when the fiscal shock is temporary. However, permanent fiscal stimuli have significantly lower multipliers at the outset,

[1] See Coenen, Erceg, Freedman, Furceri, Kumhof, Lalonde, Laxton, Lindé, Mourougane, Muir, Mursula, de Resende, Roberts, Roeger, Snudden, Trabandt and in 't Veld (2010). The institutions involved, and the related econometric models, are: the European Commission (QUEST), the International Monetary Fund (GIMF), the Board of Governors of the Federal Reserve System (with two models, FRB-US and SIGMA), the Bank of Canada (BoC-GEM), the European Central Bank (NAWM), and the OECD (OECD Fiscal).

and negative output effects in the long run.[2]

Fiscal multipliers may differ depending on whether fiscal policy is carried out through public expenditures or tax cuts, or if shocks are temporary or permanent. Due to the marginal propensity to save, multipliers should be lower for tax shocks than for spending shocks, and this is what many macroeconometric models find. However, spending expansions can be partially crowded out due to contractions in private consumption. Conversely, tax alleviations could have a large and positive impact on consumption (hence on GDP) if rational consumers expect an increase in their permanent income due to reduced distortions in the economy.[3]

It is generally agreed that a list of factors may enhance the effectiveness of fiscal policy. For instance, in the case of a fiscal expansion, the impact on output and consumption is stronger in presence of excess capacity, accommodating monetary policy, low government debt, nominal rigidities, a relatively closed economy, when additional public expenditures are not direct substitutes for private spending, when the removed taxes are distortionary and the share of "Non-Ricardian" (i.e. liquidity constrained) consumers relative to "Ricardian" ones is large (see Coenen et al. (2010)).

Obviously, some of the conditions listed above have changed over time. For instance, in advanced economies, the monetary policy stance, as measured through the evolution of real interest rates, became less accommodating in the 1980s compared to the 1970s, and more accommodating again in the late 1990 and early 2000s. During these decades, government debt generally increased, the composition of spending and tax policies varied, financial markets were deregulated and nominal wage rigidity increased (at least until the end of the 1990s) due to the fact that inflation-indexed contracts were progressively replaced by unindexed ones. Furthermore, the European economies have successively moved from the Bretton Woods system to the European snake, the European monetary system and finally the European monetary union.

As a consequence, the effects of fiscal policies may have varied throughout the last decades. Yet, the issue of time-variation of fiscal policy multipliers has been only partially explored. Blanchard and Perotti (2002) find some instability in multipliers by successively dropping different

[2]These findings are also supported by the previous literature reviews by Hemming, Kell and Mahfouz (2002) and Briotti (2005).

[3]Relying on a VAR methodology, for example, Mountford and Uhlig (2009) find tax multipliers to be higher than spending ones. Bénassy-Quéré (2006), in a two-country New Keynesian model, shows that tax shocks can be more effective than spending shocks in presence of a non-accommodating central bank.

decades in a sample of US data spanning from 1947 to 1997. Perotti (2005) studies two separate sub-samples, before and after 1980. More specifically, he shows that, for five OECD countries (US, UK, West Germany, Canada and Australia), the effects of tax and spending shocks on GDP and consumption decreased during the 1980s and the 1990s relative to previous decades. For the euro area aggregate, Kirchner, Cimadomo and Hauptmeier (2010) show that the effectiveness of government spending shocks increased from the start of the 1980s until the end of that decade, and declined thereafter. Based on data for the aggregate euro area and the US, Burriel et al. (2010) indicate that government spending multipliers rose in the 2000s in both areas. Some (indirect) evidence of varying multipliers can be also drawn by comparing a first study by Bryant, Henderson, Holtham, Hooper and Symansky (1988) and the follow-up by Bryant, Hooper and Mann (1993) on the cross-evaluation of some large scale macroeconomic models used by international institutions.[4]

Against this background, in this study we provide new evidence on time variation in fiscal policy multipliers for three OECD countries (Germany, the UK and the US), based on a novel approach applied to fiscal policy analysis. Specifically, we proceed in two steps:

First, the impact of fiscal shocks is investigated within a "factor-augmented" vector autoregression (FAVAR) model, which has been proposed for monetary policy analysis by Bernanke, Boivin and Eliasz (2005). In this context, the identification strategy developed by Blanchard and Perotti (2002) and Perotti (2005) is introduced. We study the period from 1971 (first-quarter) to 2009 (last-quarter), therefore including also part of the recent recession. For the German and British cases, three common factors capturing global shocks potentially hitting these countries are included in the baseline VAR.[5] These factors are estimated through principal components on a panel of real, nominal and financial indicators from several industrialized countries. Global factors are not included in the case of the US to avoid endogeneity problems, given that it can-

[4]In this context, evidence of diminishing multipliers might be simply due to a change in the structure of macroeconomic models used by researchers and institutions. Indeed, most models used in the 1970s and the 1980s were Keynesian in that they incorporated adaptive expectations, rigid prices and excess capacity. The latest generation of "New Neoclassical" models uses intertemporal budgeting, forward-looking expectations and removes rigidities in prices and wages, at least in the medium-long-run. These novel features tend to induce fiscal policy to be less effective and multipliers to be smaller. See Hemming, Kell and Mahfouz (2002) and McKibbin (1997) for a discussion on this point.

[5]See also Giannone and Lenza (2009) for a related application.

not be ruled out that global developments are driven by shocks originated in the US. The use of common factors has a drawback with respect to alternative global indicators, in that factors miss a clear intuition. Alternative indicators like, say, an aggregate global demand index, as for example proxied by the world output gap or a world trade index, may be useful to capture global demand shocks. In addition, other indicators, such as the oil price or the non-energy commodity price, might well capture global supply shocks. At the same time, the use of common factors has some important advantages. First, it allows to incorporate in a parsimonious way a large information set, potentially relevant for the estimation of fiscal shocks. Second, recent research has shown that the principal component analysis may help to address the 'Fiscal foresight' critique (as formalized in Leeper, Walker and Yang (2008)) by aligning the information set held by agents and the econometrician (see in particular Forni and Gambetti (2010)).

In the second step, we perform estimation of our workhorse (FA)VAR model and identification of fiscal shocks based on rolling windows of data. This allows us to assess if and how spending and tax multipliers have changed over the last thirty-nine years. We avoid to adopt a simple split of our dataset because a breakdate may be improperly imposed or not precisely estimated (see also Boivin and Giannoni (2006)). Moreover, there might be more than one regime shift, and multipliers may have not varied in a monotonic way.

Our results suggest that, over the whole sample, short-run tax and spending multipliers are broadly similar in Germany (at around 0.5). However, while the GDP reaction to spending shocks ebbs away after around one year, the tax multiplier shows more persistence. In the US and the UK, spending shocks are more effective than tax shocks in stimulating output on impact. For both countries, spending multipliers tend to zero in the longer-run.

Estimates based on rolling-windows of data suggest that fiscal multipliers have varied a lot in the last four decades, often in a non-monotonic manner. In particular, the net tax multiplier in Germany is found to follow a humped-shaped curve, peaking in the 1980s and until the mid-1990s, declining thereafter, and increasing again in the period 2008-09. The German spending multiplier increases after the German reunification, and further picks up in the last part of the sample. We show that a positive crowding-in effect for private investment following government spending expansions in the reunification period contribute to explain the rise in spending multipliers in this period. In the UK case, we observe positive short-run multipliers for windows centered in the 1970s, also underpinned by an accomodative stance of monetary policy. Then, we find evidence of non-Keynesian effects on GDP in the 1980s, in the context of the fiscal consolidation strategy followed by Margaret Thatcher's government in that decade. Finally, both UK multipliers increase somewhat in the last part of the sample. In the US, short-run multipliers appear to have been broadly stable over the period (and more significant on the spending side than on the net-tax one), but medium-run multipliers have tended to decline, in particular in the 1980s and the 1990s. This can be due to the large fiscal imbalances over this period that may have triggered Ricardian effects, before a fiscal surplus was achieved at the end of the 1990s.

As regards the recent recent 2008-09 recession and the stimulus packages implemented therein, while at the current juncture the availability of a small number of observations limits the scope for definitive conclusions, our evidence suggests a limited impact of stimulus measures in the US. Effects seem to have been more sizeable in the UK and Germany, possibly due to a higher share of liquidity constrained agents in these two countries.

Finally, results indicate that the inclusion of a large information set of global variables through principal components in a VAR model is useful for fiscal policy analysis, when (relatively) open economies are considered. However, gains in terms of data fit are moderate, especially if compared with a VAR model including US variables as proxies for global developments.

The reminder of this paper is organized as follows. Section 2 presents a review of the related literature based on VAR models. Section 3 discusses the methodology, Section 4 describes the data, Section 5 illustrates the results and focuses on a comparison between VAR and FAVAR models. Finally, Section 6 proposes a battery of robustness checks and Section 7 concludes.

2 Related VAR literature

Since the seminal paper by Blanchard and Perotti (2002), a rather vast literature has surged adopting the VAR approach to study the effects of fiscal policy shocks. This literature has been mainly focused on the US, whereas studies on European and other OECD countries have been more rare. This section reviews some of the key papers in this literature.[6]

As regards the US, Blanchard and Perotti (2002) are the first to introduce an identification scheme based on "institutional information" about the tax and transfer system in a structural VAR framework. Based on a panel of quarterly data from 1947 through 1997, they find that

[6]See also table 1 in de Castro and Hernández de Cos (2008) for a summary of findings from this literature.

fiscal policy tends to have "Keynesian" effects on output in that positive spending shocks and negative tax shocks are associated with an increase in GDP. Private consumption also increases following expansive fiscal shocks. Using US data for the period 1965-2006, Neri (2001) analyzes the interlinks between monetary and fiscal policies within a structural VAR model. He highlights that introducing fiscal policy variables in a monetary VAR model decreases substantially the response of the economy to the monetary policy shock. Mountford and Uhlig (2009) use sign restrictions to identify a tax and government spending shock over the period 1955-2000. They find that deficit-financed tax cuts are the most effective to increase GDP, with a maximal present value multiplier of five dollars of total additional GDP per each dollar of the total cut in government revenue five years after the shock. Favero and Giavazzi (2007) propose a VAR approach that takes into account public debt dynamics that arises following a fiscal shock. In this context, they allow for the possibility that taxes, spending and interest rates might respond to the level of the debt, as it evolves over time. Using data for the US economy over the period 1960-2005 and two alternative identification approaches, they find that introducing a feedback rule for public debt tends to deliver results on output similar to the benchmark Blanchard and Perotti (2002) case, while the effects on the long-term interest rate might be different for some horizons. Ramey (2009) adopts a "narrative approach" to construct a new measure of government spending shocks based on "defense news" reported in the US press (mainly in *Business Week*). Then, she incorporates such shocks in a VAR estimated over the period 1939-2008. In this framework, it emerges that output rises following the spending stimulus, but private consumption tends to be crowded-out.

As regards European countries, VAR-based studies are less numerous, although recently some new works have appeared in this field. In particular, Marcellino (2006) estimates the effects of fiscal shocks in Germany (and other three EU countries) over the period 1981-2001. He shows that spending shocks have weak effects on output in Germany, whereas the effects of tax shocks are shown to be more sizeable and of the expected negative sign. Perotti (2005) estimates the effects of fiscal shocks for five industrialized countries, including the UK. For the period 1963-2001, he shows that the response of output to spending shocks tends to be stronger than the response to tax shocks. Giordano, Momigliano, Neri and Perotti (2007) use a structural VAR model for Italy, estimated on cash data over the period 1982-2004. It emerges that government purchases of good and services have sizeable effect on economic activity in Italy, while revenue shocks have less strong effects in this country. Afonso and Sousa (2009) focus on Portugal. They estimate a Bayesian VAR model for the period 1979-2007 to find that government spending shocks have a "Non-Keynesian" (i.e. negative) impact on output as they crowd out private consumption and investment. However, tax reductions stimulate output and lead to an increase in prices. Focusing on Spain and on the period 1980-2004, de Castro and Hernández de Cos (2008) show that government expenditure expansionary shocks are associated with positive effects on output in the short-term. Tax increases are found to hamper economic activity in the medium term while entailing only a temporary improvement of the public budget balance. Weyerstrass et al. (2006)[7] analyze output spillovers across the main euro area countries, and find that fiscal expansions in one country tend to generate positive output effects in neighboring euro area countries.

Finally, Burriel et al. (2010) propose a comparison between the US and the aggregate euro area, for the period 1981-2007.[8] They find that, in general, expansionary fiscal shocks have a short-term positive impact on GDP and private consumption. Expenditure shocks have slightly higher effects than tax shocks in the euro area, whereas the differences between the effects of the two shocks is larger for the US. In addition, they show that revenue shocks have stronger effects in the euro area than in the US. Focusing on the same aggregate euro area data, Kirchner, Cimadomo and Hauptmeier (2010) show that government spending shocks tend to be associated with a forceful reaction of monetary policy to the inflationary pressures induced by the shock.

3 Methodology

The standard approach used in the VAR literature discussed above to analyze the impact of fiscal policy shocks is to incorporate in a small-scale VAR system a set of endogenous variables including a "fiscal block" (typically taxes, government spending, government deficit or public debt), a "real block" (GDP or industrial production) and a "nominal block" (interest rates, inflation).[9] When the focus is on open economies (as the European ones are commonly defined), some authors add to this baseline specification few exogenous variables (generally the contemporaneous US output gap or the US GDP, or other indicators representing global demand or supply shocks) to control for the fact that dynamics in domestic real and nominal variables might be

[7]See Weyerstrass, Jaenicke, Neck, Haber, van Aarle, Schoors, Gobbin and Claeys (2006).

[8]See Burriel, de Castro, Garrote, Gordo, Paredes and Pérez (2010).

[9]See e.g. Marcellino (2006).

influenced by external forces, as drivers for the world economy, rather than domestic fiscal shocks (see for instance Weyerstrass et al., 2006).

However, several other real and nominal indicators (for example private consumption and investments, prices, wages, interest rates and so on) might convey relevant information for the estimation of macroeconomic shocks.[10] Global indicators (such as world trade indices or energy price indices) might also be useful for the estimation of shocks. However, these indicators are typically constructed also taking into account data from the economies under investigation. This could create circularity problems, if those countries have a relatively large share of the world economy.[11]

In line with these arguments, one may want to include in the vector autoregression a larger set of variables useful to explain worldwide economic co-movements, but this approach would inevitably suffer from degrees-of-freedom-related problems.

Against this background, in this paper we borrow from Bernanke, Boivin and Eliasz (2005) and we propose an approach which allows us to summarize, in a parsimonious way, a large amount of information potentially relevant for the estimation of a fiscal VAR for open economies.

Our approach for the German and British models consists of two steps. In the first step, we assume that the world economy, represented by a large number of real and nominal indicators, is driven by few unobservable common factors. We estimate these factors by principal components. Secondly, we include them as "generated regressors" in a fiscal VAR featuring net taxes and government spending as fiscal instruments. For the US, we do not augment the VAR model with any global factors. One could ideally extract factors estimated, say, on European data. However, it would be unclear whether movements in such factors are driven by shocks originated in Europe, in the US, or elsewhere in the world. In addition, the degree of "openness" of the US economy (as measured for example by trade over GDP) is certainly minor compared with the one of the EU countries. For these arguments, the idea of modeling the US as a closed economy

[10]See in particular Altissimo, Bassanetti, Cristadoro, Forni, Hallin, Lippi, Reichlin and Veronese (2001).

[11]As regards the use of US variables, two more issues should be stressed. First, albeit the US is certainly the leading world economy, occasional peaks and throughs in the US economic cycle might have been, in some circumstances, only local and temporary, without any major effects on the rest of the world. Second, the economic cycle in the European countries looks to be not synchronized with the US one, lagging with some quarters (or years) of delay (see Croux, Forni and Reichlin (2001)). This would require the use of some (indefinite) lags of the US indicator in the system.

is not uncommon in the literature (see e.g. Smets and Wouters (2007)).

3.1 Factors estimation

Let X_t be a $N \times 1$ vector of observable economic variables which can be useful to capture worldwide economic phenomena such as the "world business cycle", "global credit conditions" or "global fiscal expansions or retrenchments". In our framework, X_t contains private consumption, private investment, industrial production, changes in stocks, hours, unemployment, labor costs, a fiscal policy indicator (general government net lending), consumer prices, three US nominal interest rates and the US composite Dow Jones index (see Appendix A.1 for a detailed data description). Importantly, except for interest rates and stock prices, we use not only US variables but also indicators for other OECD non-European Union countries (Canada, Mexico, Japan, Australia, New Zealand, Norway). This should help to capture global shocks that may originate in the US economy or in another area of the world. Moreover, this should allow us to control for possible time lags in the transnational propagation mechanism of these shocks: if cyclical indicators in quarter t rise not only in the US but also, say, in Japan, then it is likely that the shock is global and spreads contemporaneously. European Union countries are not incorporated in the panel to avoid any endogeneity problem, since it cannot be discarded that a fiscal shock in a country of the EU could affect both the domestic output and that of neighboring countries. As far as interest rates are concerned, just US variables are used. Indeed, there is little ambiguity on the fact that the US monetary policy has been the key force in explaining worldwide credit and money market conditions over the last four decades. Finally, we include a fiscal policy indicator since a fiscal expansion elsewhere in the world may spur the German and UK GDP.

We are left with 51 time series that can be used to extract few pervasive common forces likely to drive the world economy. In particular, we assume that X_t follows a factor structure as

$$X_t = \Lambda F_t + \xi_t, \tag{1}$$

where F_t is a $R \times 1$ vector of common factors ($R << N$), Λ is an $N \times R$ matrix of factor loadings and ξ_t is a $N \times 1$ vector of (weakly correlated) idiosyncratic components. We estimate F_t as the first R static principal components of the covariance matrix of X_t, after achieving stationarity of the panel as described in Appendix A.1 (see Stock and Watson (1998)). This approach, as widely documented in the factor model literature (see for example Reichlin (2002) and Forni, Hallin, Lippi and Reichlin (2005)), is particularly successful in capturing, in a parsimonious way, co-movements between a large number of variables. We select the "static rank" R equal to three, following Bai and Ng (2002)'s Information Criteria.[12]

3.2 A "factor-augmented" VAR for fiscal policy analysis

In order to explore the transmission of German, UK and US fiscal shocks to domestic economies, we propose a VAR model where we include five endogenous variables: net taxes (n), government spending (g), GDP (y) (all in logs, and in real per capita terms); the GDP deflator annual inflation rate (p) and the 10-years nominal interest rate (i).[13] The model includes four lags of the endogenous variables, given the quarterly nature of the series employed, and it is estimated equation by equation by OLS.

As in the "ST" (stochastic trend) case of Blanchard and Perotti (2002), before estimation we transform variables in first-differences, given the non-stationary nature of our data.[14] Impulse responses generated from the VAR in first-differences are then cumulated. Therefore, all charts report the level response of variables.[15] Our baseline specification is the following:

$$Y_t = A(L)Y_{t-1} + BF_t + CW_t + u_t, \tag{2}$$

where Y_t is the $M \times 1$ vector of endogenous variables (here, $M = 5$), L is the lag operator for $A(L) = 1 - A_1 L - \ldots - A_k L^k$, F_t the $R \times 1$ vector of estimated latent stationary factors

[12] Section 6 shows some robustness exercises where one and two latent factors ($R = 1$, $R = 2$) are successively considered.

[13] This is similar to Perotti (2005). See also Appendix A.2 on data description.

[14] A battery of unit root tests is performed to check for stationarity in the data . Table 1 reports results for the Augmented Dickey Fuller (ADF) and Elliott, Rothenberg and Stock (1996) (ERS) tests. The latter allows for a level shift in variables, and it is used to control for German reunification effects. Both the ADF and the ERS tests speak strongly against stationarity.

[15] VAR models can be also consistently estimated in levels. This is done for the whole 1971-2009 sample, and results are reported in Table 3. However, the rolling-window analysis indicates that, for some windows of data (especially in the 1970s and the 1980s), impulse responses of the level VAR are explosive. This is due to the fact that, in these windows, some roots of matrix A in model (2) lie outside the unit circle. Therefore, we use the difference specification as baseline, given that it does not deliver explosive impulse responses.

$(R = 3)$,[16] $B = [b_1, b_2, b_3]$ where b_i is a $M \times 1$ vector of factor loadings, u_t the $M \times 1$ vector of correlated reduced-form residuals and W_t a vector of additional exogenous variables including a constant.[17] For the German model, which is estimated using data for West Germany for the period before 1990:4 and for unified Germany for the period starting in 1991:1 (see also Section 4), we include a dummy in 1991:1 to control for the reunification effects, as in Lütkepohl and Wolters (2003) and Lütkepohl and Brüggemann (2006).[18]

We include the estimated factors as exogenous regressors. In fact, it is unlikely that British and German variables influence global developments (as represented by the estimated factors), given that these two countries are relatively small compared to the rest of the world. In addition, this choice simplifies the identification procedure. In fact, it would be unclear whether common factors should be ordered before or after the other endogenous variables in the VAR, given that such factors are estimated on both "fast moving" (e.g. nominal and financial) and "slow moving" (e.g. real) variables.[19]

The proposed specification may help to address, at least to some extent, the "Fiscal foresight" critique, as put forward by Leeper, Walker and Yang (2008). According to this critique, in an environment characterized by rational expectations, economic agents adopt their decisions as soon as they have information on future changes in fiscal policy. If this is the case, the information set of the agent and the econometrician might be different, and estimates based on quarterly VAR including fiscal variables may be biased, given that estimated fiscal shocks are anticipated. However, Heppke-Falk and Wolff (2006) address this problem by including indicators of future fiscal policy measures, and they find results qualitatively similar to a standard VAR. The inclusion of interest rates and common factors, as in the present paper, may also help to mitigate the problem. Indeed, Yang (2007) shows that when including lagged short rates and prices, responses to a tax shock are lower. This implies that lagged interest rates and prices contain information about macroeconomic variables related to current tax changes and suggests

[16] Note that model (2) incorporates "generated" regressors. We rely on the arguments set forth by Bai (2003) and we treat the estimated factors as known.

[17] Quarterly dummies have also been added to the vector of control variables but they turn out to be not significant.

[18] We have also experimented to adjust variables for reunification effects by prolonging the series for unified Germany backwards, for quarters before 1991, with West-German growth rates, as in Heppke-Falk and Wolff (2006). Results are however broadly unchanged.

[19] see Bernanke, Boivin and Eliasz (2005) for a discussion on this point.

that including these variables may help to reduce the foresight problem. In addition, Forni and Gambetti (2010) show that fiscal shocks estimated through a factor model approach are not Granger-caused by Professional Forecasters' projections. This implies that also the inclusion of latent factors should contribute to mitigate the fiscal foresight issue.

Table 2 shows the marginal contribution of incorporating the common factors F_t, into a fiscal VAR model. Columns (1) to (3) display the absolute values of the t statistic associated with the estimated factor loadings $\hat{B}$, for each equation in the German and British country models. The first factor turns out to be highly significant especially for GDP, but also for net taxes and interest rates. The second factor is significant only in the German model (for the net taxes and GDP equation), while the third factor is significant for the inflation equation in the German model, and for interest rates in the British model. Columns (4) to (11) compare the data fit of the FAVAR model with respect to three competing models. The fit is evaluated based on the adjusted R^2 statistic and the Akaike Information Criterion (AIC), which both contain a penalization term for additional regressors. The three competing models are the following: (i) a VAR model including the US output gap and the interest rate on the 10-years US government bond as control variables ("VAR+US"); (ii) a VAR including the world output gap and two indices for energy and non-energy commodity price inflation ("VAR+WD")[20]; (iii) a simple VAR without any exogenous variable representing global factors. The Akaike criterion indicates that the FAVAR model generally performs better, although the improvement appears limited, especially with respect to the model incorporating US variables. The improvement is small for Germany, and more sizeable for the UK. In turn, the R^2 statistics, which is computed for each equation in the model, suggest that the FAVAR model fits the data generally in line, or better, compared with the alternative models. The improvement is evident for the GDP equation. This is particularly relevant in the present context, given our interest in measuring the size of GDP multipliers.[21]

3.3 Identification of fiscal shocks

We follow Blanchard and Perotti (2002) and Perotti (2005) for the identification of net taxes and government spending shocks. The strategy consists of using "institutional" and economically

[20]The world output gap is computed by applying the Hodrick-Prescott filter to the world GDP series published by the OECD.

[21]Section 5.4 will be devoted to a comparison of impulse response functions from these four competing models.

meaningful information to pin down some relations linking the reduced form residuals u_t and the "structural", uncorrelated shocks, that we label as ε_t.[22] Defining as $M1$ and $M2$ the matrices of coefficients linking the vectors of reduced form and structural residuals, we have:

$$M1u_t = M2\varepsilon_t. \tag{3}$$

Then, the idea is to calibrate some coefficients in $M1$ and $M2$ using "out of model" information and to estimate the remaining ones, under a condition of orthogonality on the resulting (unobserved) structural shocks. Rewriting (3), we obtain:

$$\begin{bmatrix} 1 & 0 & \alpha_{ny} & \alpha_{np} & \alpha_{ni} \\ 0 & 1 & \alpha_{gy} & \alpha_{gp} & \alpha_{gi} \\ \gamma_{yn} & \gamma_{yg} & 1 & 0 & 0 \\ \gamma_{pn} & \gamma_{pg} & \gamma_{py} & 1 & 0 \\ 0 & 0 & \gamma_{iy} & \gamma_{ip} & 1 \end{bmatrix} \begin{bmatrix} u_t^n \\ u_t^g \\ u_t^y \\ u_t^p \\ u_t^i \end{bmatrix} = \begin{bmatrix} 1 & \beta_{ng} & 0 & 0 & 0 \\ \beta_{gn} & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ \beta_{in} & \beta_{ig} & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^n \\ \varepsilon_t^g \\ \varepsilon_t^y \\ \varepsilon_t^p \\ \varepsilon_t^i \end{bmatrix}. \tag{4}$$

We proceed as follows. First, a set of zero restrictions are imposed on $M1$ and $M2$ under the assumption that unexpected movements and structural shocks to some variables do not have any effect on unexpected movements in other variables. For instance, due to transmission delays, it is assumed that $u_t^p, u_t^i, \varepsilon_t^p$ and ε_t^i do not have any contemporaneous effect on unforecastable changes in output (u_t^y) and that ε_t^p and ε_t^i do not affect unexpected inflation variations (u_t^p).

Second, the α parameters are pinned down using institutional information. In particular, the parameter α_{ny} represents the contemporaneous reaction of fiscal policy to changes in GDP. The key step in the identification procedure consists of considering that a short-term reaction of u_t^n to u_t^y should be nothing else than automatic stabilization. In other words, an unexpected rise in taxes in quarter t following an unexpected increase in GDP in quarter t is not likely to be the consequence of a discretionary fiscal action, since fiscal authorities need time to observe GDP movements, to approve possible stabilizing measures, and to implement them.

Lastly, the γ parameters are derived by recursively regressing, starting from the first equation, residuals u_t^z on u_t^j and ε_t^j (for $z \neq j$).

[22] This approach was originally proposed by Shapiro and Watson (1988). A related application, in the field of monetary policy analysis, is Bernanke and Mihov (1998).

An intuitive way to read the equations in this system is to think of them as reaction functions. The first equation, for instance, implies that net taxes respond automatically to contemporaneous and lagged innovations in output, prices and the interest rate. Furthermore, they move in response to random discretionary shocks to fiscal variables. The last equation can be interpreted as an "augmented Taylor-rule" where interest rate movements follow changes in output and prices, but also in fiscal variables, beside being determined by exogenous monetary shocks ε_t^i.

By estimating the output and price sensitivities of single items adding up to the public receipts indicator n, we obtain α_{ny} equal to 1.38 for Germany, 1.33 for the UK and 1.41 for the US. As for α_{np}, we get respectively 1.05, 0.93 and 1.16 (see Appendix A.3 for elasticities construction). The price elasticity of real spending is set equal to -0.5. This figure is based on the fact that at least half of nominal public spending (basically wages) do not react to price increases within the same quarter whereas the other half (purchases of goods and services, notably drugs and health-related expenditures) is perfectly indexed. When converting public spending into volumes, we end with a -1 elasticity in the first case and a 0 elasticity in the second one, hence to an average of -0.5. As in Perotti (2005), we assume that α_{ni}, α_{gy} and α_{gi} are zero, since there is no reason to predict that taxes and spending respond in the same quarter to movements in the interest rate[23] and that spending should respond contemporaneously to output. We are left with a vector of orthogonal structural shocks ε_t, with an economically meaningful interpretation.

4 Data

Small-scale multivariate models, such as VARs and FAVARs, offer an interesting framework to trace out the impact of policy shocks on the economy. One limitation in using these econometric tools is however the need of data with a relatively high (e.g. quarterly or monthly) frequency in order to avoid degrees-of-freedom problems in estimation and because many identification procedures rely on discarding a number of short-run contemporaneous relationships. In this paper, identification hinges on the assumption that taxes do not react in the same quarter to output fluctuations as a consequence of discretionary policy actions (see previous Section 3.3).

The lack of quarterly data for fiscal variables reduces the scope for applying a VAR-type of methodology to several countries. At the same time, quarterly fiscal data in line with national

[23] Note that the g variable is constructed netting off interest payments on public debt.

accounts are available for the UK and the US starting from at least 1970. These data are also reported in the OECD Economic Outlook Database. For Germany, quarterly fiscal data in line with national accounts standards are available from 1999:1, and for West Germany from 1970 until 1990:4. In the interval from 1991:1 to 1998:4 (which represents only around 20% of our 1971-2009 sample), quarterly data are available just for government consumption and investment, as they are part of national account statistics. For the remaining fiscal variables, and in particular for revenue components, the OECD has produced interpolated series. The method applied by the OECD is not based on a simple statistical interpolation from annual data, but relies on the use of macroeconomic tax bases as guides. All in all, we believe that - as in Marcellino (2006) - the inclusion of this span of data has informational content which is relevant for fiscal analysis.[24] In sum, data for the endogenous variables are taken from the OECD Economic Outlook (No. 86, November 2009) quarterly database (see also Appendix A.2). Data used for the estimation of common factors are described in Appendix A.1.

5 Macroeconomic effects of fiscal shocks

5.1 Full sample estimation

Impulse response functions (IRFs) for the sample spanning from 1971:1 through 2009:4 are reported in Figure 1, 2 and 3. The baseline IRFs (red-middle lines) are reported together with the 90% confidence intervals (light-grey areas) and the 68% confidence intervals (dark-grey areas). The latter choice is standard in the empirical literature based on fiscal VAR models.[25] Fiscal shocks are normalized to be equal to one percent of domestic GDP. Impulse responses for all variables have been cumulated to revert the first-difference transformation used for OLS estimation. Therefore, reported impulse responses can be read as changes in percent of GDP (fiscal variables, output) or in percentage points (inflation, interest rate).

For Germany (Figure 1), the response of GDP to both shocks is similar at short horizons, and in particular on impact. The impact multiplier is 0.69 for net tax shocks, and 0.46 for

[24] A database based on cash indicators for the central government published by the German Ministry of Finance has also been collected and used for estimation of impulse response functions. Results from this exercise are available upon request.

[25] See e.g. Blanchard and Perotti (2002), Canzonieri, Cumby and Diba (2003), Perotti (2005) and Mountford and Uhlig (2009).

government spending shocks. The GDP response to tax shocks is however more persistent, while the GDP reaction to spending shocks fades away after around one year. The latter effect may be driven by the observed tightening of the interest rate, possibly due to the financial market reaction to deteriorating fiscal positions, which crowds out private consumption. Inflation rises following a spending shock, but only in the same quarter. Inflationary pressures are stronger following the tax shock, due to the more persistent expansionary effects on output of such shock. Working on the pre-reunification period (1960-1989), Perotti (2005) also finds a positive impact of a spending shock on GDP. He finds a negative short-term multiplier for the net tax shock, although the multiplier turns significantly positive after a few quarters.

As for the UK (Figure 2), the impact reaction of GDP to both shocks is positive, but lower than in the German case: the impact spending multiplier is 0.28, and the net-tax one is 0.12 (statistically significant at the 68% level). Inflation and the interest rate react positively to these expansionary shocks. This is in part explained by the short-run expansionary impact on output, but also by the inclusion of the 1970s in the sample. When this period characterized by high and volatile inflation is dropped from the sample, results indicate that the reaction of inflation to fiscal shocks declines drastically.[26] In our view, this also justifies an approach based on rolling-windows of shorter samples of data, and proposed later in Section 5.2. There is evidence of a strong reaction of the interest rate in the medium-run, again possibly as a consequence of the financial market reaction to expanding public deficits. Based on the 1963-2001 period, Perotti (2005) also finds relatively small effects of fiscal shocks on output and a sizeable reaction of the interest rate.

Figure 3 zooms in on the reaction of US variables to fiscal impulses. Our finding suggest that the government spending shock is more powerful in stimulating output on impact and in the short-run than the tax shock (this is also in line with Perotti (2005)). The spending multiplier is larger than one on impact (1.30). This estimate appears to be on the high-side of the range of multipliers found in the VAR literature for the US. For example, Perotti (2005) and Burriel et al. (2010) find impact multipliers for the US to be around unity, and other short-term multipliers

[26] CPI annual inflation averaged at 12.6% in the UK during the 1970s, compared to 7.1% in the US and 4.9% in Germany. According to Howard (1981), the inflationary impact of fiscal and monetary measures decided in the UK in the 1970s was magnified by the change in the financial structure in 1971 and also by the decision to index wages to prices.

(i.e. multipliers equal or below to the one year horizon) to be below one. At the same time, other papers find short-run US spending multipliers to be above unity. For example, Bryant, Henderson, Holtham, Hooper and Symansky (1988), reporting results from 12 macroeconomic models for the US, highlight that the average short-term multiplier is 1.27.[27] As regards the longer-horizons, Figure 3 shows that the impulse responses to both shocks are not different from zero. In both cases, inflation and interest rates are hardly affected.

On the whole, we note that tax shocks seems to be more effective in spurring output in Germany. In the UK and even more in the US, spending shocks appear more powerful, in particular on impact and for the short-run. These results are broadly confirmed from a specification of the model in levels, as discussed more in detail in Section 6.

An analysis based on such a long sample of observations might be contaminated by the presence of one (or more) structural break in the variables and in the relations among them. In addition, estimates may be strongly affected by periods characterized by high volatility in macro variables (as for the UK case, for inflation).

To test whether there is statistical evidence of parameters instability in our models, we apply the Chow (1960) test to each reduced-form VAR equation (see also Ahmed, Levin and Wilson (2004)). The test has been developed for known breakpoints. Therefore, given that we have little a-priori information on where a breakpoint (if any) may be located, we perform the test repeatedly, assuming in each round that the breakdate is set at a different quarter in the 1971:1-2009:4 sample, after trimming the 15% of observations at the beginning and at the end of the period. The null of the test is the joint stability of all parameters in each equation. Figure 4 reports results from this test, together with the 95% critical value (horizontal line). The test indicate that for Germany a breakdate can be clearly located at the beginning of the 1990s, during the re-unification period. However, some equations (in particular, inflation) display an F-statistic above the acceptance region also during the 1980s. The UK case indicates the possible presence of several break dates, especially during the 1980s and the 1990s, while from mid-1990s onwards estimates are more stable. The US case shows that most F-statistics are well above the

[27] Adams and Klein (1991) and Coenen et al. (2010) also tend to find short-term multipliers above unity. In particular, Coenen et al. (2010), based on several structural models from central banks and international organizations, show that US short-term spending multipliers are estimated to be relatively large if the fiscal shock is temporary.

critical value at the end of the 1970s and beginning os the 1980s (consistently with the "Great Moderation" hypothesis, see e.g. Stock and Watson (2003)), although there is no indication of a clear breakdate (see also Boivin and Giannoni (2006)). However, the F-statistics for inflation and net taxes rise again towards the end of the sample. All in all, these results suggest that a simple split of a long sample in two or three sub-sample may be inappropriate. In fact, the coefficients in many equations show a lot of instability in the last forty years, and identifying single breakdates is generally problematic.[28]

5.2 Evolving GDP multipliers: rolling window analysis

We subsequently perform a rolling-window analysis, based on the estimation of model (2) and identification of fiscal shocks over successive intervals of data. This approach helps to avoid a loss of information on regime shifts, and to capture possible non-monotonic effects in the time-variation of fiscal multipliers. We select a window a 17 years of data. This choice is clearly arbitrary, but results are broadly robust using alternative windows. Starting from the 1971:1-1987:4 window, we repeat estimation and identification of fiscal shocks by moving the starting date by one quarter and keeping the sample size constant to 17 years.[29]

Figures 5, 6 and 7 trace out the GDP impulse responses (point estimates) for Germany, the UK and the US over different samples and horizons to (tax and spending) shocks equal to 1% of GDP. The left-horizontal axis reports the 17-years windows over which the impulse response are estimated, e.g. the first impulse response is the one associated with 1971:1-1987:4 window, the last impulse response with the 1993:1-2009:4 window. The right-horizontal axis represents the

[28] We have also applied the Quandt-Andrews unknown breakpoint test (see Andrews (1993)) equation by equation to our models, and its multivariate version developed by Bai, Lumsdaine and Stock (1998). While these tests often reject the null of stability for single parameters in the models, they tend to accept the null when jointly testing stability for all parameters. However, these tests are known to have low power when many parameters are included in the model, for relatively small samples (see Andrews, Lee and Ploberger (1996)). Each equation of our model includes 24 parameters (Germany and UK) and 21 ones for the US.

[29] This exercise is similar to Canova (2006) who recursively estimates a DSGE model to explore possible changes in the conduct of the US monetary policy. However, in each step not only we estimate the system, but we also implement shocks identification. This approach has a lower level of econometric sophistication compared to alternative time-varying VAR approaches (see e.g. Primiceri (2005)). However, it has the advantage that several identification schemes (such has the one by Blanchard and Perotti (2002)) can be applied in a tractable way in each step.

horizon of these impulse responses. The vertical axis indicates the size of the GDP multiplier, which is expressed in percent of GDP. The reactions of variables at the 1st and 8th quarter horizons are plotted in Figures 8 through 10, where filled-markers indicate 90% significance and empty-markers denote 68% significance.

Our results generally show non-monotonic evolutions of fiscal multipliers, supporting our rolling-window approach. This pattern is especially marked in Germany, where the net-tax multiplier follows a hump-shaped evolution peaking for windows centered around the 1980s and 1990s (Figure 5a and 8a): in these windows, the GDP impact multiplier reaches a peak of around 2 while the 2-years multiplier rises to a maximum of around 1.5. Both the first-quarter and the eight-quarter multipliers diminish for windows exceeding the mid-1990s to values not-statistically different from zero or even slightly negative. Both tax multipliers pick up somewhat in the very last periods, when the impact multiplier reaches around 0.5. As highlighted by Figure 5b and 8b, the spending impact multiplier follows a different pattern. In particular, it is non-significant over the first decades of the sample. Then, it rises and becomes statistically significant for windows that include the post-reunification period, when it reaches values around unity. A positive crowding-in effect for private investment following increases in government consumption and investment over this period contributes to explain the higher spending multipliers in the reunification period. Indeed, as shown in Figure A.4.1 in Appendix A.4, when we include private investment in the baseline FAVAR model for Germany,[30] government spending shocks are found to have non-significant (or even negative) effects on private investment in the 1970s and the 1980s, but positive and significant impact effects in the second part of the sample. This is consistent with the evidence that, in years following the reunification, the massive public investment plans directed to Eastern Germany were accompanied by new investments by private companies and enterprises from West Germany. Indeed, in 1991 the German parliament approved a law (the so-called *'Fördergebietsgesetz'*) providing tax incentives to Western German firms investing in Eastern regions.[31] Finally, the increase of the tax and spending multiplier for the last regression windows could be possibly influenced by the impact of the German stimulus package implemented

[30] Private investment is added as additional endogenous variable and ordered last in the baseline model (2). However, results are broadly unchanged when a different ordering is used.

[31] See official legislative act (in German) at $http://www.gesetze-im-internet.de/bundesrecht/f_gbg/gesamt.pdf$.

during the recent 2008-2009 recession, a period also characterized by increasingly binding credit constraints.

Results for the UK are reported in Figure 6 and 9. For the periods centered around the 1970s, impact multipliers are found to be positive and significant both for spending and for net tax shocks, but the 8-quarters multipliers are either non-significant or negative. An accomodative monetary policy stance for this period (as also documented in Howard (1981)), which reinforces the effects of the fiscal stimulus, contributes to explain the positive short-run reaction of output: in the same quarter in which an expansive fiscal shock occurs the nominal interest rate either declines (spending shock) or rises much less than inflation (net tax shock). Such an accomodative monetary and fiscal policy mix tends to boost the fiscal multiplier in the short run but to depress it in the medium-run when financial markets realize that the policy mix is unsustainable, as reflected in rising interest rates for longer horizons.

Subsequent rolling windows show a drop in British fiscal multipliers, consistent with the reversal of economic policy in the 1980s with monetary tightening and large spending cuts during the mandate of Margaret Thatcher. Indeed, rolling windows centered in the 1980s suggest non-significant impact multipliers and a non-Keynesian reaction of GDP to (especially spending-based) fiscal shocks in the medium term. The latter can be interpreted as GDP reacting positively to government spending reductions (i.e. Figure 9 can be equivalently read inverting the sign of the shock and of all other impulse responses). This is consistent with the literature on large-scale consolidation episodes, where non-Keynesian effects are mostly explained through the implications of permanent reductions in the level of government spending (see e.g. Alesina and Perotti (1996)). For the spending shock, the declining medium-term multiplier in these years can be also explained by the fact that the share of public investment in the spending shock (which is here defined as government consumption plus investment) went down from around 20% in the 1970s to less than 10% in the 1980s.[32]

Both fiscal multipliers become very small or non-significant in the 1990s, consistent with the

[32]Indeed, the finding that spending multipliers tend to be associated with the share of government investment is consistent with Kirchner, Cimadomo and Hauptmeier (2010) and Benetrix and Lane (2009), who show that spending shocks tend to be more effective when they are more intensive in government investments. This is in line with the idea that government investment may have non negligible supply-side effects, in addition to the aggregate demand effect through absorption.

completion of the financial liberalization process that tend to be associated with a reduction of fiscal multipliers through less-binding liquidity constraints for agents. Multipliers rise again in the last periods. Output increases by about 1%, at the 2-years horizon, following the spending shock for windows including 2008 and 2009. The output reaction to the net tax shock is weaker (around 0.5), but still significant at the 68% level. Developments in the last periods can be related to the 2008-09 global crisis and to the stimulus programme of the British government, which included measures on both the spending and the tax side (a temporary cut in the standard VAT rate), in an environment of tightening credit constraints.

The US case shows a high, relatively stable (at around 1.3) impact spending multiplier throughout the period (see Figures 7b and 10b). The long-term multiplier is generally not-statistically significant, but declines to negative values (significant in few cases at the 68% level) in the 1980s and 1990s. This can be possibly due to large cumulated deficits that may have triggered Ricardian effects, before a fiscal surplus was achieved at the end of the 1990s.[33] This result is consistent with Bilbiie, Meier and Müller (2008), who also evidence a fall in the spending multiplier in the 1980s and 1990s. As for the tax multiplier, it is weakly significant throughout the period, and sometimes negative for longer horizons. Focusing on the end of the sample, it appears that stimulus measures implemented in the context of the American Recovery and Reinvestment Act of 2009 have not been more effective than in the past to stimulate output.[34] This finding is consistent with Taylor (2010) who stresses the lack of correlation between disposable income and consumption in the United States during the 2009 net-tax cut episode. At the same time, while the availability of a small number of observations for the recent crisis suggests to be cautious to derive conclusions for this period, our results for Germany and the UK seem to support the view that expansive fiscal policies have been more effective during the recent severe recession. This could be due to the presence of a higher share of credit-constrained agents in these two countries during the crisis. When households and firms face more difficulties to access to credit markets

[33] Based on a VAR model estimated on US data, Corsetti, Meier and Müller (2009) show that spending stimulus plans are only effective when they are followed by a reversal over the medium term. Failing to produce such sustainability expectations reduces the effectiveness of the fiscal stimulus.

[34] This does not imply that stimulus measures have not been successful overall in this country, given that short-run multipliers (and especially the spending one) are positive and because the systematic reaction of US fiscal policy is not taken into account here. However, based on available data, our evidence suggests that the *effectiveness* of shocks seems to have not increased in the last period compared to previous periods.

and smooth investment and consumption over time, in fact, fiscal shocks tend to be more effective as agents consume or invest the extra unit of income generated by the fiscal expansion.[35]

5.3 Variance decomposition

Next, we study how important fiscal shocks have been in contributing to GDP dynamics throughout our sample. To this aim, we implement a forecast error variance decomposition exercise over the rolling samples of data and different horizons. Figure 11 shows that, in Germany, net tax shocks explain up to 40 percent of output variability in the 1980s and beginning of 1990s. Spending shocks contribute to less than 6% over almost the whole period of observation, except for the beginning of the sample and a (minor) peak when the early 1990s are considered. These findings may be related to the German reunification that involved large fiscal impulses, both on the spending side and on the net-tax (transfer) one. In addition, the contribution of spending shocks peaks at around 15% for longer horizons.

Results for the UK (Figure 12) and the US (Figure 13) are even more clear-cut, pointing to a virtually ineffective role of non-systematic fiscal policy, especially in more recent years: in the UK, fiscal shocks account for at most 10% of GDP forecast error variance up to the end of the 1980s, less than 2% afterwards. In the US, both net taxes and spending shocks contribute to at most 7% of GDP variance.

Variance decomposition results depend on the size of impulse response coefficients in the moving average representation of the VAR and FAVAR models, but also on the variance of structural shocks. The variance of our estimated government spending shocks shows a clear downward trend for the whole period for the US and UK, and for the last few years for Germany.[36] However, the variance of net tax shocks have been broadly stable in these three countries. In the light of the recent debate on the "Great Moderation", suggesting a more virtuous monetary

[35]See also Tagkalakis (2008) and Roeger and in't Veld (2009). The former author finds that, for a panel of OECD countries, a spending shock has a larger effect on private consumption in downturns than in upturns. In a DSGE model calibrated on EU data, Roeger and in't Veld (2009) show that - especially in severe recessions - the presence of credit constrained households raises the marginal propensity to consume out of transitory tax reductions and increases in transfers, and makes fiscal policy a more powerful tool for short run stabilization. Finally, Burriel et al. (2010) find that spending multipliers have increased in the recent years in both the US and the euro area.

[36]These estimates are not reported, but they are available from the authors.

policy as the main cause behind the observed drop in the volatility of economic activity during the last decades (see for example Stock and Watson (2003)), these results indicate that less volatile government spending policies have also contributed to dampen fluctuations in the economic cycle.

5.4 Comparing fiscal VAR and FAVAR models

In table 2 we showed results, in terms of data fit, for the FAVAR incorporating three unobservable common factors for the world economy compared with a VAR augmented by US key variables (VAR+US), a VAR augmented with the world output gap and two global (energy and non-energy) price indices (VAR+WD), and with a simple VAR model without any controls representing global economic phenomena.

Figure 14 zooms in on the differences in terms of impulse response functions from these four competing models. For Germany, Figure 14a shows that the impulse responses to a net tax shock are similar across the four models. However, at long horizons the VAR model tends to deliver higher responses to net tax shocks, while the FAVAR model produces stronger responses to spending shocks, compared to the other models, as documented by the red-circled lines. The UK case is more conclusive in that both tax and spending multipliers are stronger at short horizons and smaller (in absolute values) at long horizons when the FAVAR model is used (Figure 14b). This evidence points to the fact that, at least for the UK, the inclusion of a richer information set (as summarized by the common factors F_t) in a prototypical VAR model leads to a moderation in long-term multipliers estimates.

6 Robustness checks

Table 3 reports the results from several robustness exercises. The first quarter (1q) and two years (8q) GDP multipliers estimated through ten different specifications are shown. Columns (1) and (2) summarize the results from the baseline model, based on the impulse responses shown in Figures 1, 2 and 3.

Columns (3),(4),(5) and (6) report estimates based on a FAVAR specification which includes only one or two factors as exogenous regressors. For Germany, the GDP multiplier to net tax shocks appears to be stable at around 0.70, both on impact and at the 8-quarter horizon. For the UK, net tax shocks insignificantly affect GDP, while spending shocks have a positive and significant impact multiplier, that tends to fade away at the longer horizon, as in the baseline case. The following two experiments are based on a FAVAR model that includes three contemporaneous factors together with three factors lagged by one quarter (columns (7) and (8)); and three contemporaneous factors, three factors lagged by one quarter together with three factors lagged by two quarters (columns (9) and (10)). Again, results turn out to be very stable and comparable to the ones from the baseline specification.

Columns (11) and (12) present results for models incorporating only one lag for endogenous variables, and three contemporaneous factors. For Germany, multipliers are slightly lower, but still significant at the 90% level for the net tax shock (both on impact and at the 8-quarter horizon) and the spending shock (on impact). For the UK, the GDP reaction to net tax shocks becomes significant at both horizons. The impact multiplier to spending shocks turns non-significant, albeit the point estimate is broadly in line with the baseline estimate. For the US, results are very similar to the baseline. The impact multiplier to the spending shock is still above unity, but somewhat lower that in the model with four lags of endogenous variables.

Results based on FAVAR and VAR models estimated with endogenous variables and common factors in levels are reported in columns (13) and (14). A specification in levels is common in the literature (see e.g. Mountford and Uhlig (2009), Burriel et al. (2010)), although some papers adopts a specification in first differences as the one of this paper (see e.g. "ST" case in Blanchard and Perotti (2002)). In the German and British FAVARs, three non-stationary common factors are included as controls. They are estimated first by computing static principal components on the panel of variables listed in Appendix A.1, properly transformed to achieve stationarity. Then, the static factors are cumulated over time as suggested by Bai and Ng (2004), and included as exogenous regressors. Results generally indicate that the GDP reaction to shocks tends to fade away more quickly, which is the consequence of shocks displaying less persistence than in the first-differences (baseline) case.[37] This is evident for Germany (net tax shock) and the US (spending shock). For the UK, the GDP response to spending shocks tends to be somewhat higher, both on impact and at the 8-quarter horizon. As concerns the impulse response to net tax shocks, it turns negative at the 8-quarter horizon (but then reverts to zero at longer horizons).

Next, we repeat the exercise by replacing our output and price elasticities to taxes and

[37] See also Blanchard and Perotti (2002) for a comparison between a fiscal VAR estimated in first differences and in levels.

spending with the one estimated by Perotti (2005). Columns (15) and (16) show that, for Germany, the GDP reaction to net tax shocks in somewhat lower, but still significant at both horizons, while the GDP reaction to spending shocks is somewhat higher, and significant on impact as in the baseline case. These differences are clearly the consequence of elasticities estimated over two different periods of time. At the same time, multipliers for the UK and Germany are very similar to baseline case.

Finally, the last two robustness checks are based on the inclusion of two additional endogenous variables, which are added to the baseline model and ordered last. Column (17) and (18) report estimates for a model including total employment, and column (19) and (20) include the CPI-based real effective exchange rate. In both cases, the GDP responses to net tax and spending shocks is similar to the baseline estimates.

7 Conclusions

In this paper, we propose a factor-augmented VAR approach combined with identification of fiscal shocks *à* la Blanchard and Perotti (2002) and Perotti (2005) to study the evolution of fiscal multipliers in Germany, the UK and the US.

Compared to world demand or supply indices, the use of principal components in a VAR framework has the limitation that factors miss a clear interpretation. However, it has some important advantages. First, it allows to incorporate in a parsimonious way a large information set, potentially relevant for the estimation of fiscal shocks and fiscal policy analysis. Second, it helps to reconcile the information set of agents and the econometrician, and therefore to address the 'Fiscal foresight' critique of Leeper, Walker and Yang (2008).

Based on a sample of thirty-nine years of data ranging between 1971 and 2009, and on rolling-windows of data, our results suggest the following:

Over the whole sample, short-run tax and spending multipliers are broadly similar in Germany (around 0.5). Spending shocks are more effective than net tax shocks in stimulating output in both the UK and the US, and for the short-run. In the US, the short run spending multiplier is above one, while in the UK it is substantially lower (around 0.30). In all cases, multipliers fade away at longer horizons, except for the net tax shock in Germany.

Results based on rolling-windows of data suggest that fiscal multipliers have generally exhibited a lot of time variation in the last four decades. In addition, multipliers have often varied in a non-monotonic way, justifying our rolling-windows approach. In particular, the German net tax multiplier increased until the middle of the 1990s, and declined thereafter, before rising again during the recent 2008-09 crisis. In turn, the spending impact multiplier increased after the German reunification. We show that this can be due to crowding-in effects for private investment. For the UK, we observe large variations in fiscal multipliers over the period, with non-Keynesian developments for GDP during the fiscal consolidation period of the 1980s, under the mandate of prime minister Margaret Thatcher. After that, British multipliers are low and only pick up at the very end of the sample, when the 2008-09 crisis is included in the analysis. In the US, short-run multipliers appear broadly stable over the period, but medium-run multipliers have tended to decline, in particular in the 1980s and the 1990s. This can be due to the large fiscal imbalances over this period that may have triggered Ricardian effects, before a fiscal surplus was achieved at the end of the 1990s.

As regards the recent 2009-09 crisis period and the stimulus packages implemented therein, while at the current juncture the availability of a limited number of observations prevent to derive definitive conclusions, we find a limited impact of the stimulus measures in the US. At the same time, the effects of stimulus packages seem to have been more sizeable in UK and Germany, possibly due to a higher share of liquidity constrained agents in these two countries.

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Table 1: Augmented Dickey Fuller (ADF) and Elliott, Rothenberg and Stock (ERS) unit root tests. Sample: 1971:1 - 2009:4.

Variable	Germany		United Kingdom	United States
	ADF	ERS	ADF	ADF
Net Taxes	-2.16	0.51	-0.83	-2.90
Gov. Spending	-0.64	2.00	2.31	2.16
GDP	-1.13	0.58	-1.38	-1.73
Inflation	-3.00	-1.96	-4.38	-2.36
Interest rate	-1.83	-0.87	-1.80	-1.67

Note: The ADF and ERS tests include four lags of the dependent variable, a constant and a linear trend.

ADF test critical values	1% level:	-3.47
	5% level:	-2.88
	10% level:	-2.57
ERS test critical values[a]	1% level:	-3.58
	5% level:	-3.03
	10% level:	-2.74

[a] See Elliott et al. (1996), Table I.C, T=100.

Table 2: Significance of factor loading coefficients and fit comparison between FAVAR, VAR including US variables as controls, VAR including global variables and VAR without exogenous regressors.

	FAVAR			**FAVAR**	**VAR+US**	**VAR+WD**	**VAR**	**FAVAR**	**VAR+US**	**VAR+WD**	**VAR**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	b_1 *t-stat*	b_2 *t-stat*	b_3 *t-stat*	Adj. R^2				AIC			
				Germany				-33.88	-33.85	-33.78	-33.68
Net Taxes	**2.82**	**2.13**	0.55	0.59	0.58	0.59	0.56				
Gov. Spending	1.18	0.32	0.18	0.53	0.54	0.54	0.53				
GDP	**5.32**	**3.15**	0.50	0.46	0.38	0.39	0.31				
Inflation	1.82	0.01	**2.28**	0.57	0.54	0.54	0.55				
Interest rate	**2.86**	1.66	0.19	0.18	0.26	0.18	0.13				
				United Kingdom				-29.50	-29.27	-29.21	-29.18
Net Taxes	**2.60**	0.38	0.80	0.15	0.11	0.13	0.12				
Gov. Spending	0.70	1.91	0.74	0.01	0.00	-0.02	0.00				
GDP	**5.90**	1.59	1.90	0.30	0.10	0.08	0.10				
Inflation	0.23	0.26	0.84	0.30	0.30	0.32	0.31				
Interest rate	**2.61**	1.11	**3.43**	0.14	0.17	0.13	0.04				

Notes: Columns (1), (2) and (3) report the absolute values for the t-statistics on factor loading coefficients in the FAVAR model (2) for Germany and the United Kingdom. Bold figures indicate 95% significance. Columns (4), (5), (6) and (7) display, equation by equation, the adjusted R^2 statistics for the baseline FAVAR models and models incorporating 1. the US output gap and interest rate on the 10-years US government bond as exogenous variables (VAR+US); 2. the world output gap plus oil and non-energy commodity price inflation indices (VAR+WD) (source: BIS for commodity prices. The world output gap is calculated from the world real GDP series published by the OECD); 3. and a VAR model without any controls (VAR). Columns (8), (9), (10)) and (11) compare the Akaike Information Criterion (AIC) corresponding to the FAVAR, VAR+US, VAR+WD and VAR specifications. Sample: 1971:1-2009:4.

Table 3: Robustness Checks: GDP multipliers from different specifications.

		Baseline[a]		**R = 1**[b]		**R = 2**[b]		**F-lags = 1**[c]		**F-lags = 2**[c]		**k = 1**[d]		**Levels**[e]		**Perotti**[f]		**empl.**[g]		**reer**[h]	
		1q	8q	1q	8q	1q	8q	1q	8q	1q	8q	1q	8q	1q	8q	1q	8q	1q	8q	1q	8q
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
	shock																				
Germany	n	**0.69**	**0.65**	**0.69**	**0.78**	**0.69**	**0.69**	**0.68**	**0.64**	**0.70**	**0.65**	**0.62**	**0.34**	**0.59**	0.06	**0.43**	**0.46**	**0.66**	**0.61**	**0.70**	**0.70**
	g	**0.46**	0.08	**0.47**	0.15	**0.46**	0.22	**0.47**	0.05	**0.48**	0.02	**0.27**	0.34	**0.38**	-0.04	**0.57**	0.18	**0.51**	-0.10	**0.44**	0.06
UK	n	0.12	-0.12	0.14	-0.02	0.12	-0.07	0.12	-0.07	0.12	-0.05	**0.20**	**0.23**	0.18	**-0.38**	-0.07	-0.30	0.13	-0.13	0.11	-0.16
	g	**0.28**	-0.11	**0.20**	-0.63	**0.27**	-0.38	**0.30**	-0.02	**0.29**	0.04	0.22	0.30	**0.42**	**0.40**	**0.31**	0.08	**0.29**	0.01	**0.28**	-0.06
US	n	-0.09	-0.16									-0.12	-0.26	-0.15	-0.24	0.06	0.05	-0.04	0.01	-0.09	0.45
	g	**1.30**	-0.73									**1.07**	0.75	**1.33**	-0.20	**1.32**	-0.70	**1.24**	1.14	**1.33**	1.57

Notes: This table reports the one quarter and eight quarter GDP multiplier to net taxes (n) and government spending (g) shocks equal to one percent of domestic GDP. Ten different specifications of the model are considered (bold indicates 90% significance):

a. Baseline FAVAR (Germany and UK) and VAR model (US). For FAVAR models, three factors are included as regressors.

b. One and two factors (R = 1, 2) are included as regressors in FAVARs.

c. Specifications including three contemporaneous factors and factors at lag 1 (F-lags = 1); contemporaneous factors, factors at lag 1, and factors at lag 2 (F-lags = 2) as regressors in FAVARs.

d. Number of lags of endogenous variables in FAVAR and VAR models (k) = 1.

e. Models estimated with endogenous variables and factors variables in levels. In the German and UK FAVARs three non-stationary common factors are included as controls. They are estimated first by computing static principal components on the panel of variables listed in Appendix A.2, properly transformed to achieve stationarity. Then, the static factors are cumulated over time as suggested by Bai and Ng (2004).

f. Tax and Spending elasticities estimated by Perotti (2005) are used. In particular, α_{ny} and α_{np} are set equal to 0.92, 0.76, 1.85 and 0.87, 1.21, 1.25 for Germany, the UK and the US respectively. α_{gp} is unchanged at -0.5 since this is the same value used by Perotti.

g. VAR and FAVAR models include total employment (source: OECD Economic Outlook No. 86) as additional endogenous variable.

h. VAR and FAVAR models include the real effective exchange rate (CPI-based, source: BIS) as additional endogenous variable.

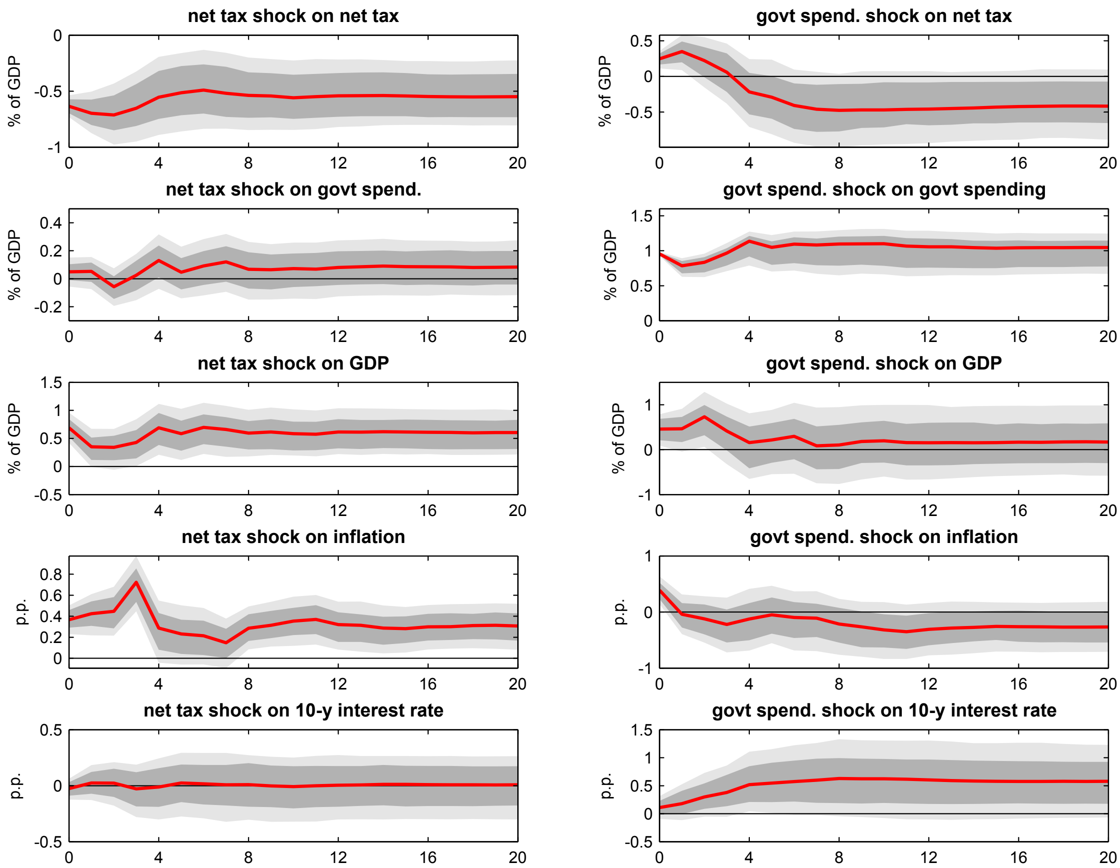

Figure 1: Germany. Effects of a shock to real per capita net receipts (n) and government spending (g) equal to one percent of German GDP on n, g, real per capita GDP (y), inflation and the nominal interest rate on the 10-years government bond. Red lines: baseline impulse responses. Dark-grey area: 68% confidence bands. Light-grey area: 90% confidence bands. Number of bootstrap replications: 1000. Sample: 1971:1 - 2009:4.

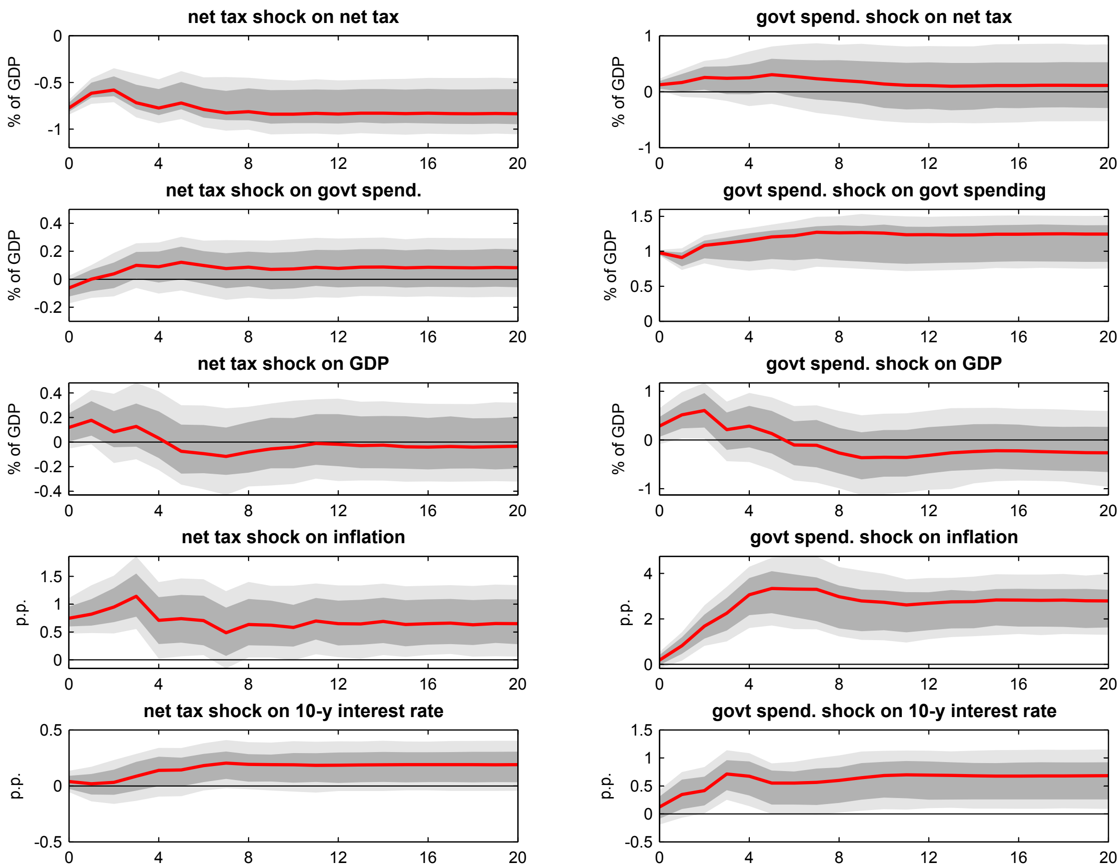

Figure 2: United Kingdom. Effects of a shock to real per capita net receipts (n) and government spending (g) equal to one percent of UK GDP on n, g, real per capita GDP (y), inflation and the nominal interest rate on the 10-years government bond. Red lines: baseline impulse responses. Dark-grey area: 68% confidence bands. Light-grey area: 90% confidence bands. Number of bootstrap replications: 1000. Sample: 1971:1 - 2009:4.

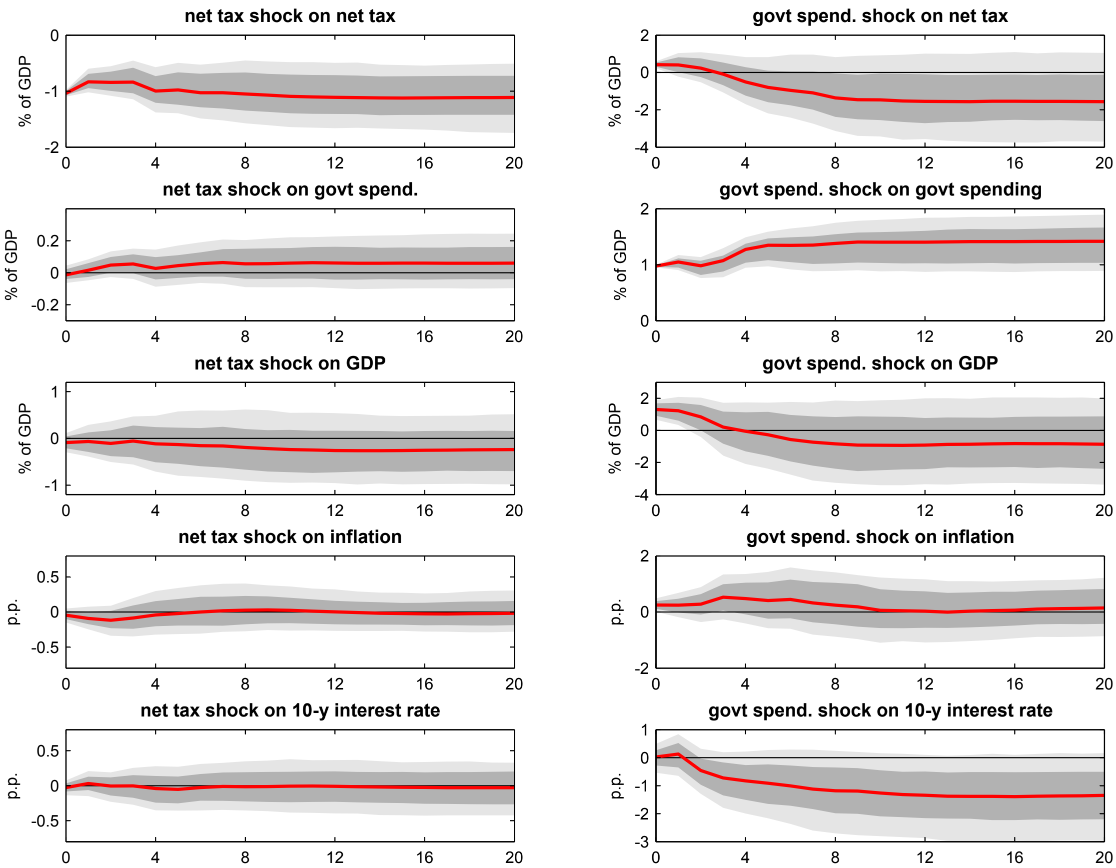

Figure 3: United States. Effects of a shock to real per capita net receipts (n) and government spending (g) equal to one percent of US GDP on n, g, real per capita GDP (y), inflation and the nominal interest rate on the 10-years government bond. Red lines: baseline impulse responses. Dark-grey area: 68% confidence bands. Light-grey area: 90% confidence bands. Number of bootstrap replications: 1000. Sample: 1971:1 - 2009:4.

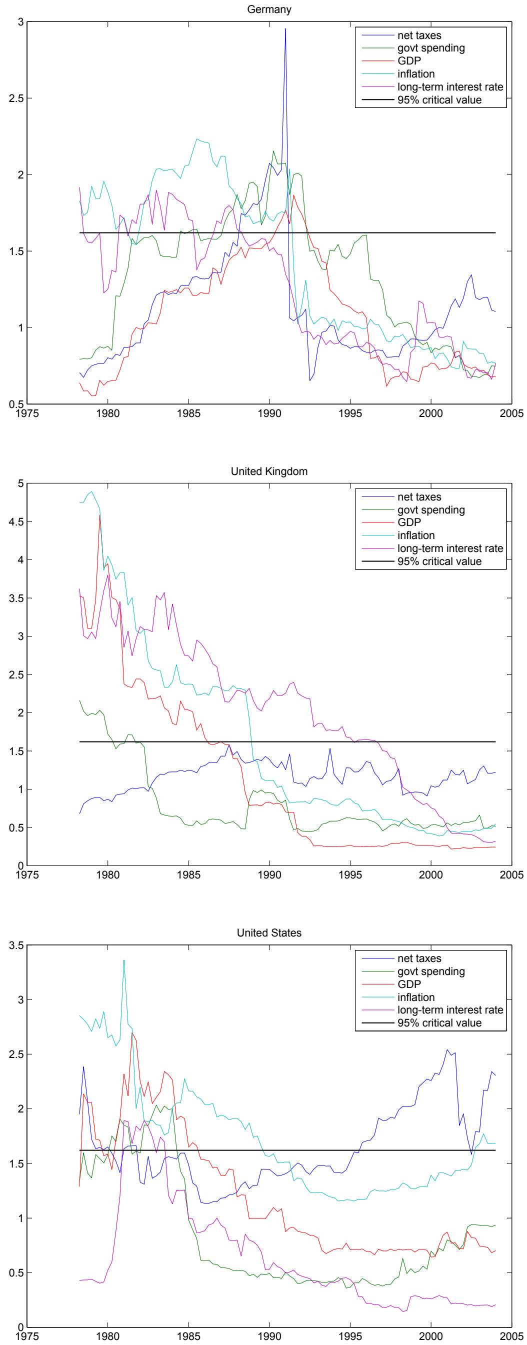

Figure 4: Charts report the F-statistic from the Chow (1960) breakpoint test applied equation by equation for FAVAR models (Germany and UK) and the VAR model for the US. The test is applied for each quarter in the sample, after trimming the 15% of observations at the end and at the beginning of the 1971:1-2009:4 period. The black line indicates the 95% critical value of the F-statistic (1.62 for Germany and the UK, 1.65 for the US).

Figure 5a: Effects of German net tax shocks on German GDP over different samples.

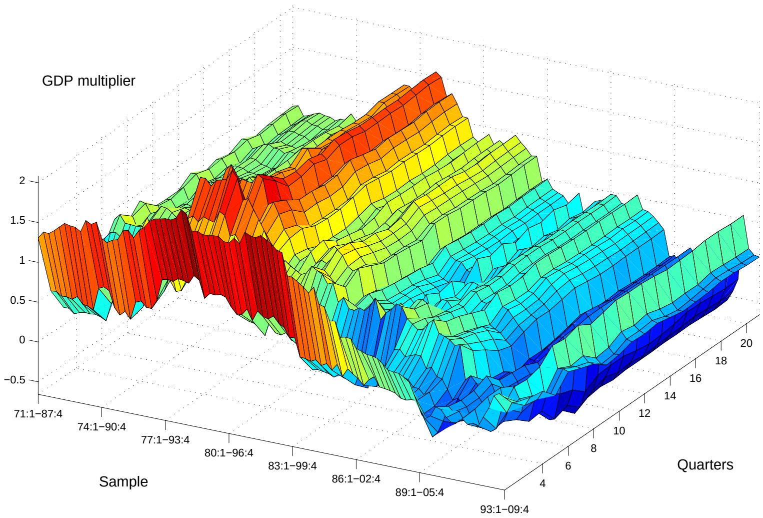

Figure 5b: Effects of German gov. spending shocks on German GDP over different samples.

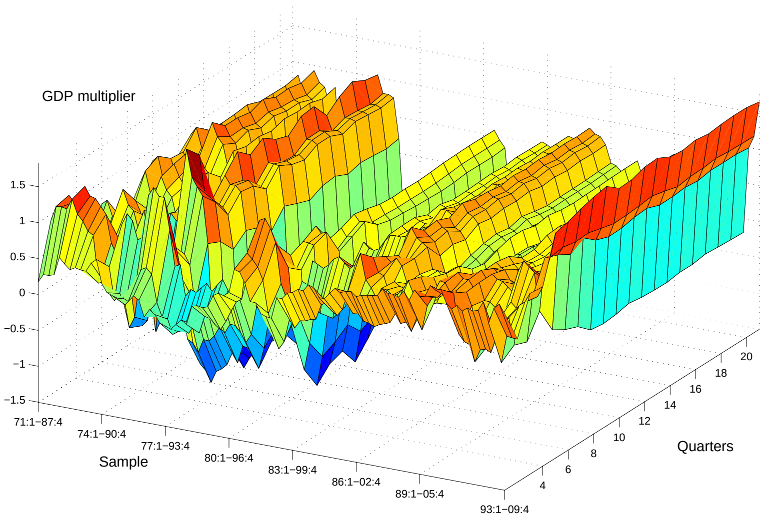

Figure 5: Germany. Recursive estimate of impulse response functions over 17-years rolling samples of data. Percentage response of domestic GDP to a domestic negative tax shock (Figure 5a) and domestic positive government spending shock (Figure 5b) equal to one percent of GDP.

Figure 6a: Effects of UK net tax shocks on UK GDP over different samples.

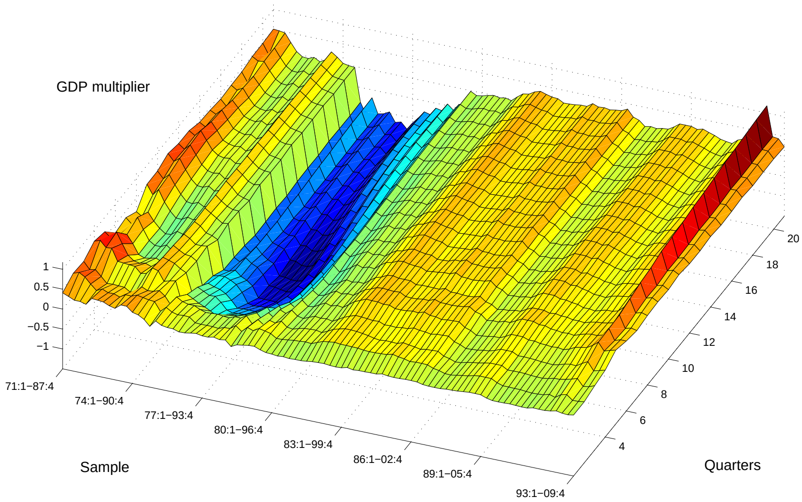

Figure 6b: Effects of UK gov. spending shocks on UK GDP over different samples.

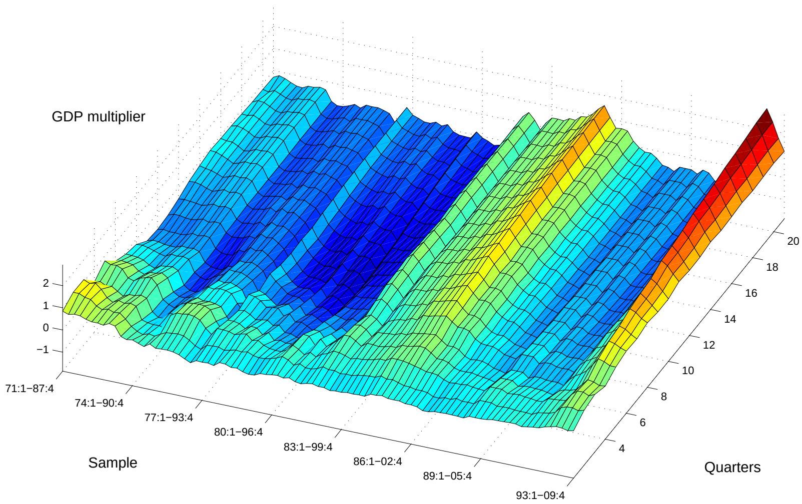

Figure 6: United Kingdom. Recursive estimate of impulse response functions over 17-years rolling samples of data. Percentage response of domestic GDP to a domestic negative tax shock (Figure 6a) and domestic positive government spending shock (Figure 6b) equal to one percent of GDP.

Figure 7a: Effects of US net tax shocks on US GDP over different samples.

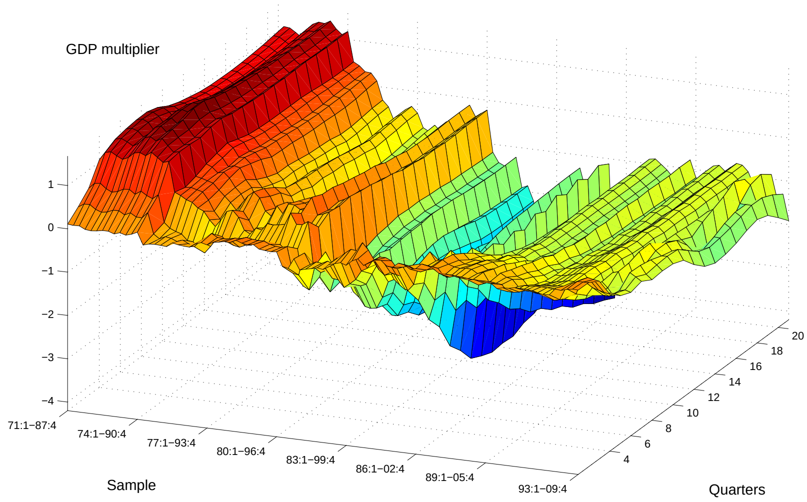

Figure 7b: Effects of US gov. spending shocks on US GDP over different samples.

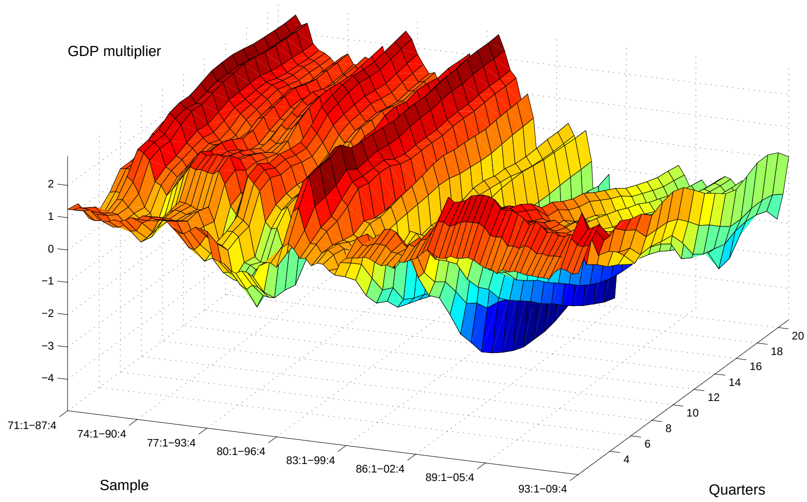

Figure 7: United States. Recursive estimate of impulse response functions over 17-years rolling samples of data. Percentage response of domestic GDP to a domestic negative tax shock (Figure 7a) and domestic positive government spending shock (Figure 7b) equal to one percent of GDP.

Figure 8a: German net taxes shock

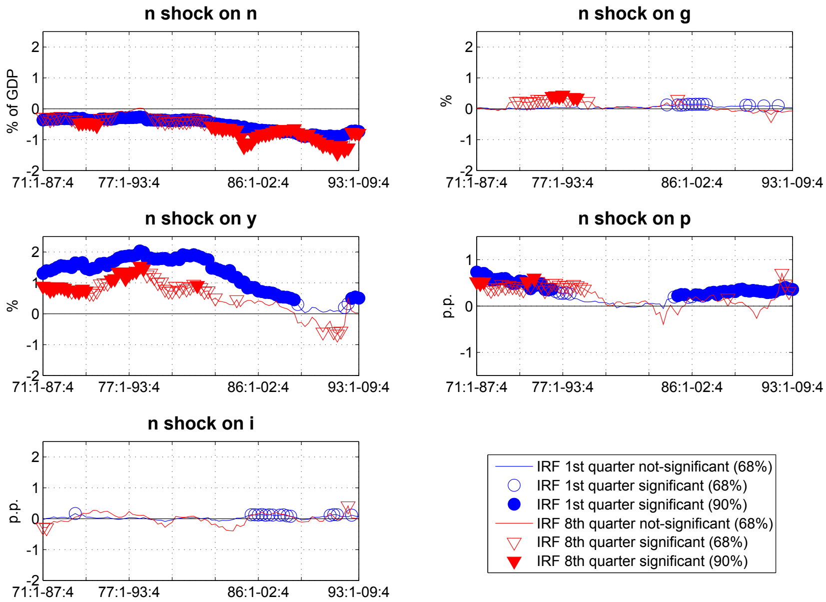

Figure 8b: German gov. spending shock

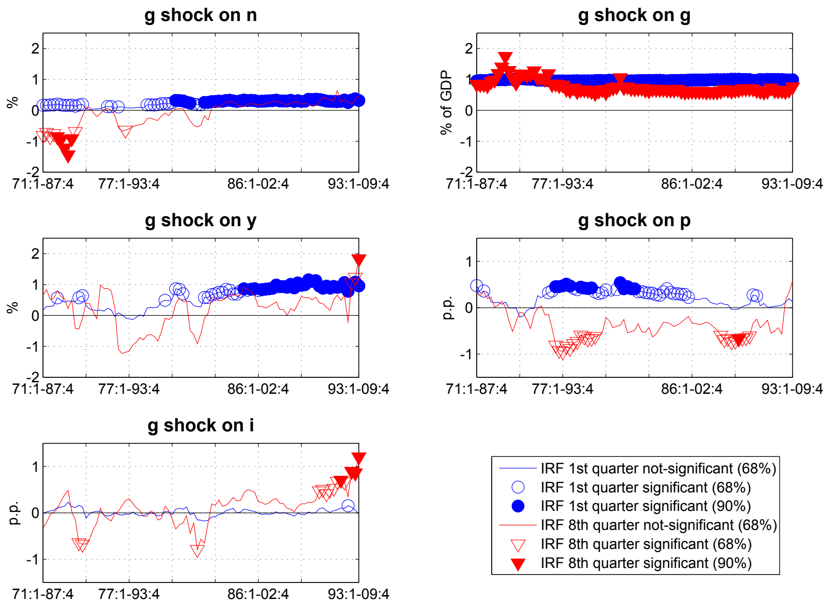

Figure 8: Germany. Rolling window estimate of impulse response functions over 17-years rolling samples of data. Effects of net taxes shocks (Figure 8a) and government spending shocks (Figure 8b) equal to one percent of domestic GDP. Blue lines are short-term multipliers (one quarter IRFs), red lines the two years multipliers (8 quarters IRFs). Filled markers indicate 90% significance, empty markers 68% significance over the corresponding data window.

Figure 9a: UK net taxes shock

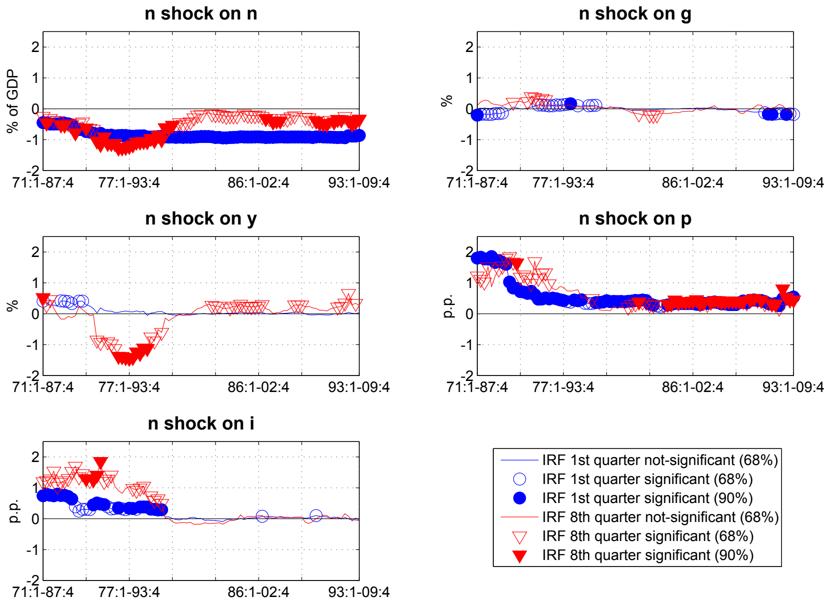

Figure 9b: UK gov. spending shock

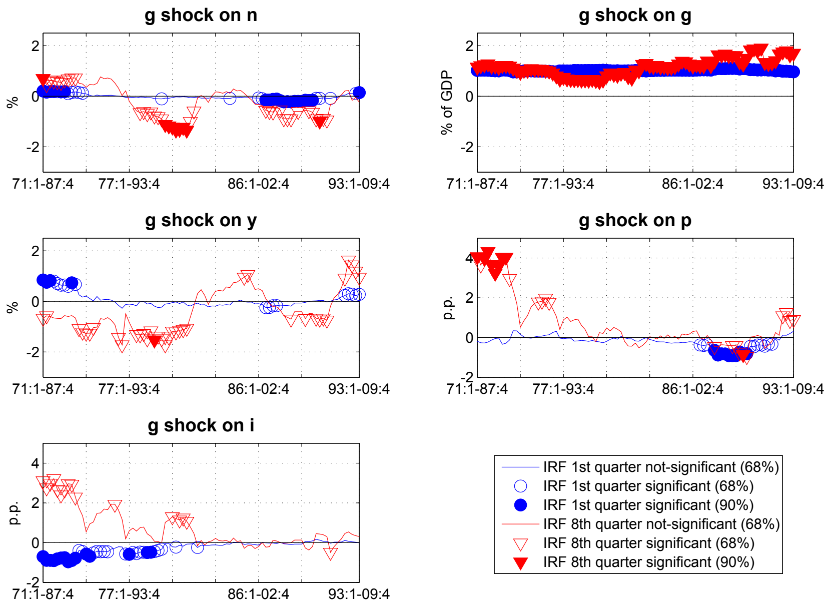

Figure 9: United Kingdom. Rolling window estimate of impulse response functions over 17-years rolling samples of data. Effects of net taxes shocks (Figure 9a) and government spending shocks (Figure 9b) equal to one percent of domestic GDP. Blue lines are short-term multipliers (one quarter IRFs), red lines the two years multipliers (8 quarters IRFs). Filled markers indicate 90% significance, empty markers 68% significance over the corresponding data window.

Figure 10a: US net taxes shock

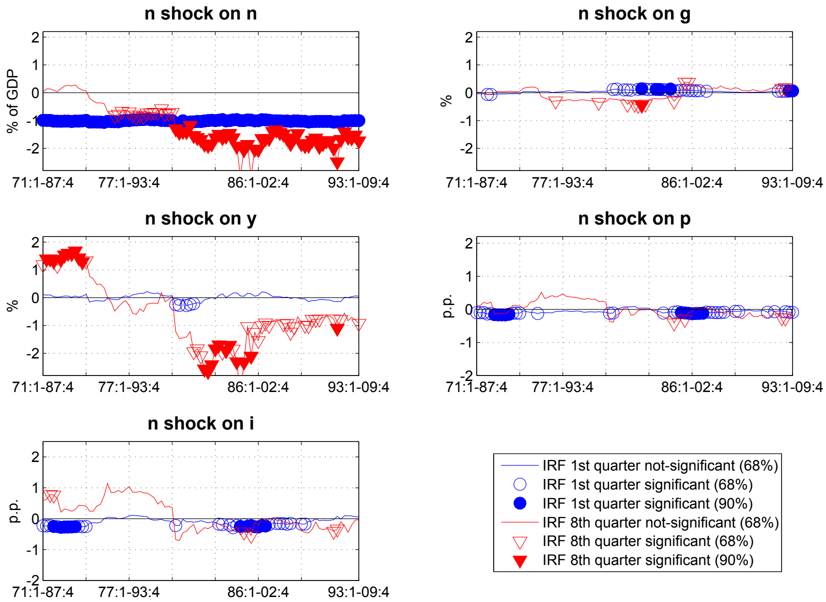

Figure 10b: US gov. spending shock

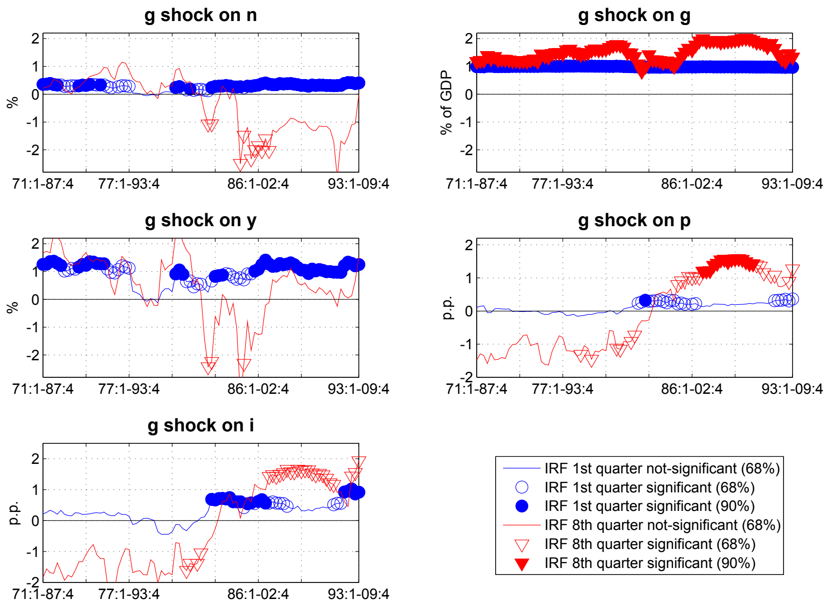

Figure 10: United States. Rolling window estimate of impulse response functions over 17-years rolling samples of data. Effects of net taxes shocks (Figure 10a) and government spending shocks (Figure 10b) equal to one percent of domestic GDP. Blue lines are short-term multipliers (one quarter IRFs), red lines the two years multipliers (8 quarters IRFs). Filled markers indicate 90% significance, empty markers 68% significance over the corresponding data window.

Figure 11a: GDP variance due to net tax shocks

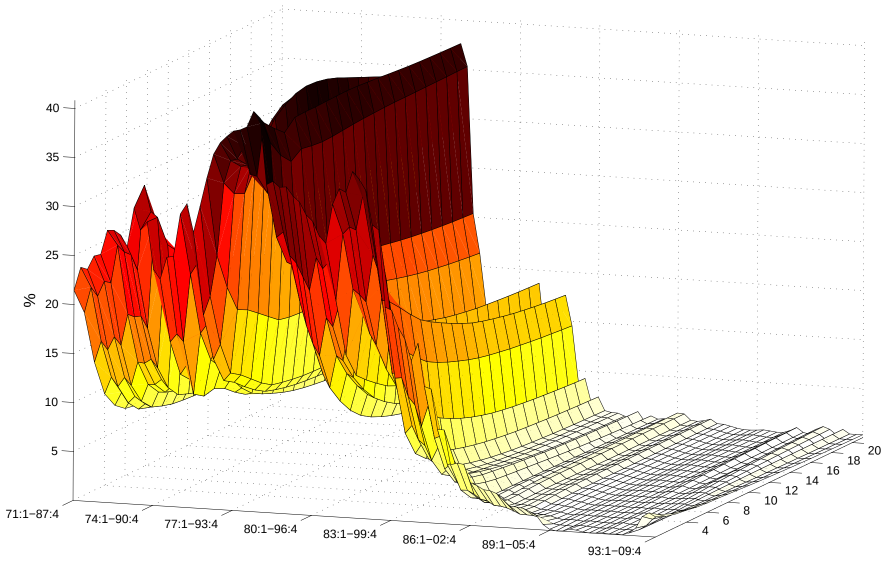

Figure 11b: GDP variance due to government spending shocks

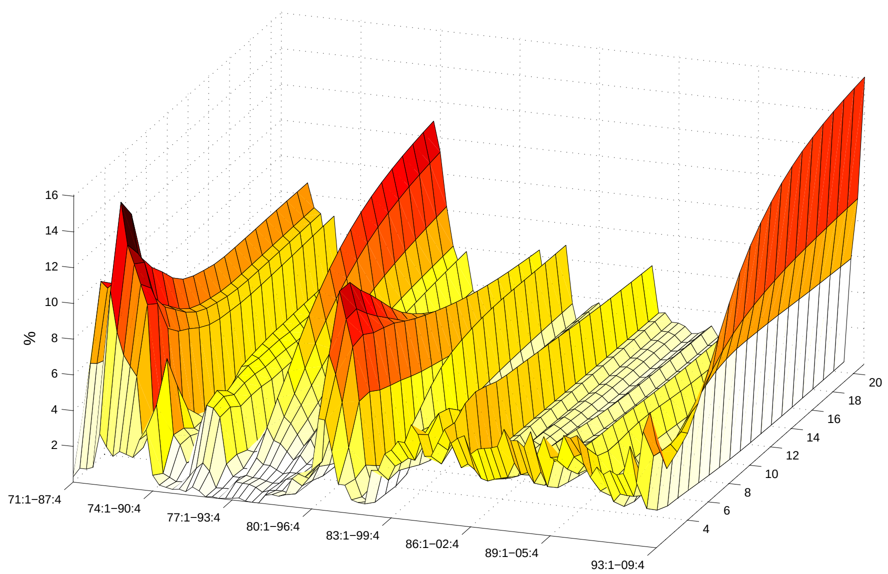

Figure 11: Germany. Forecast error variance decomposition. Percentage of GDP variance explained by net tax shocks (Figure 11a) and government spending shocks (Figure 11b) over different horizons and data samples.

Figure 12a: GDP variance due to net tax shocks

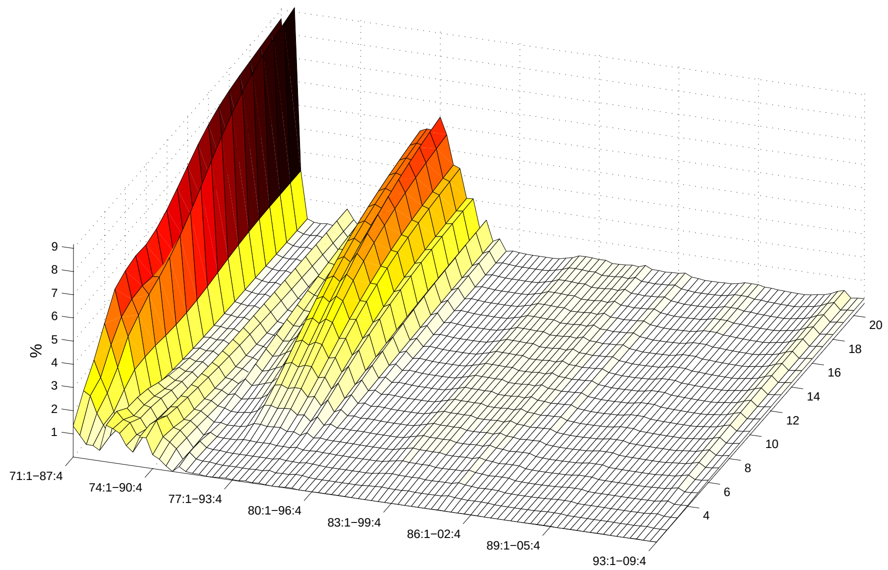

Figure 12b: GDP variance due to government spending shocks

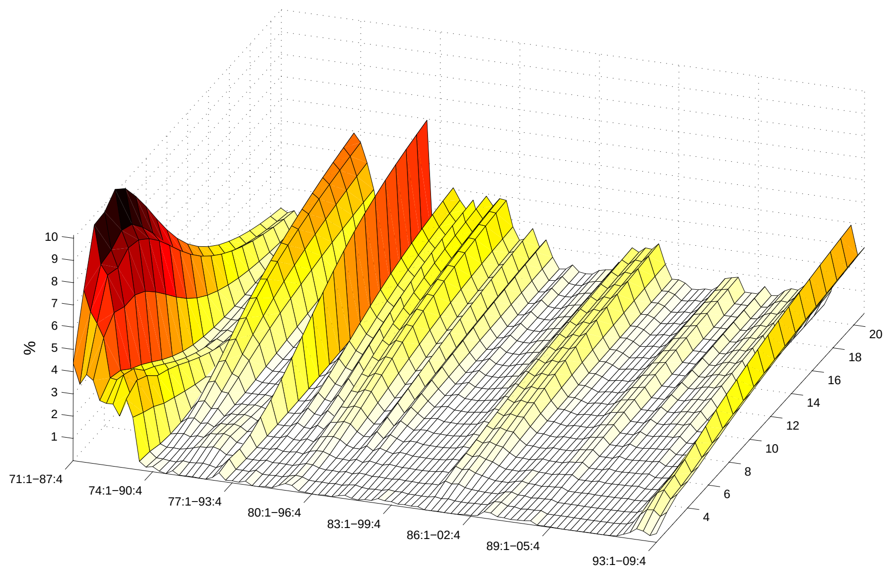

Figure 12: United Kingdom. Forecast error variance decomposition. Percentage of GDP variance explained by net tax shocks (Figure 12a) and government spending shocks (Figure 12b) over different horizons and data samples.

Figure 13a: GDP variance due to net tax shocks

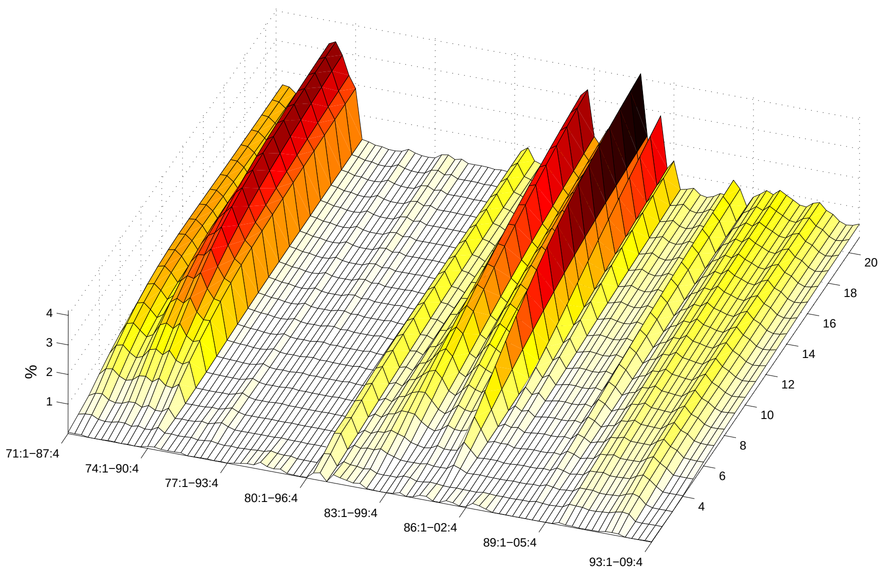

Figure 13b: GDP variance due to government spending shocks

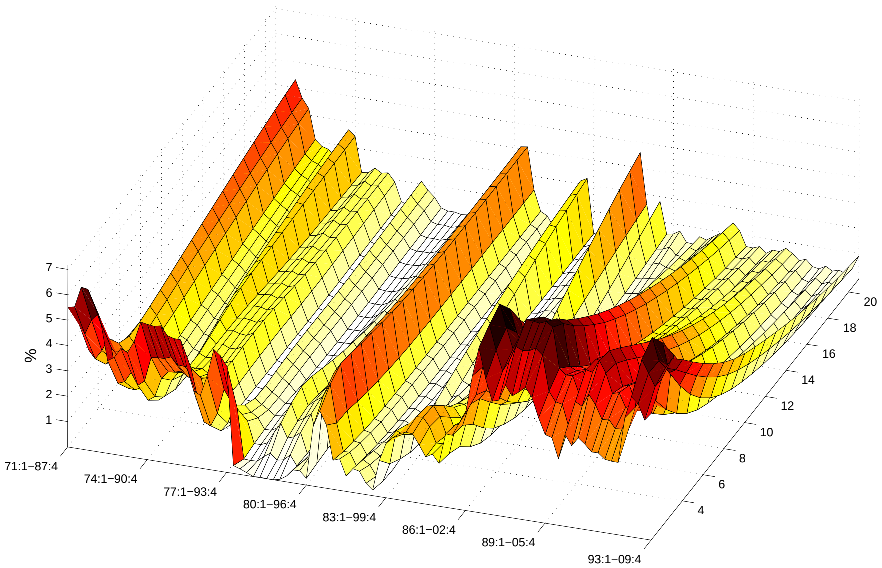

Figure 13: United States. Forecast error variance decomposition. Percentage of GDP variance explained by tax shocks (Figure 13a) and government spending shocks (Figure 13b) over different horizons and data samples.

Figure 14a: Germany. GDP Impulse responses.

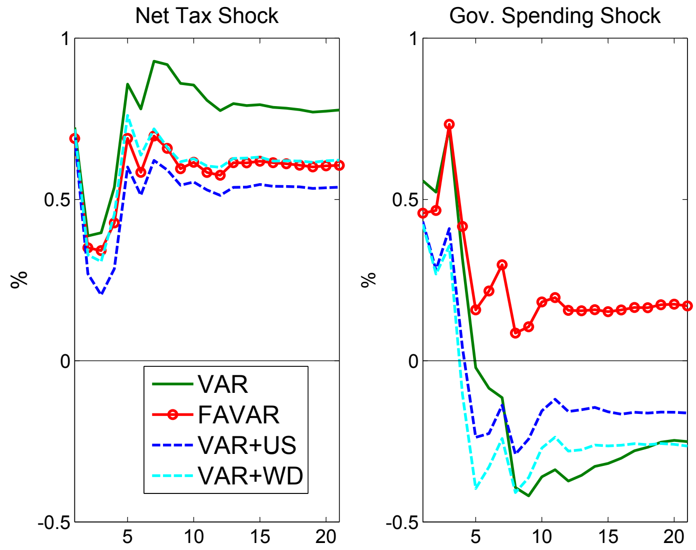

Figure 14b: United Kingdom. GDP Impulse responses.

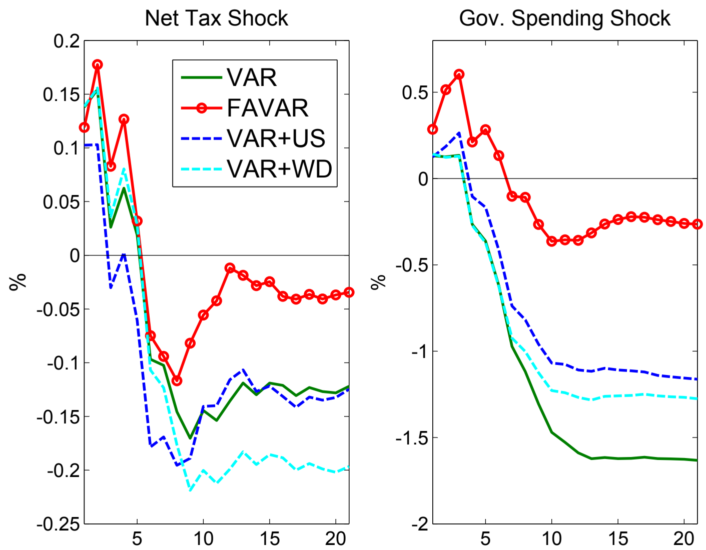

Figure 14: Comparison between the baseline fiscal FAVAR in model (2) (red-circled line) and: 1. a VAR model including the US output gap and the interest rate on the 10-years US government bond as control variables ("VAR+US", blue-dashed line); 2 a VAR including the world output gap and two indices for energy and non-energy commodity price inflation ("VAR+WD", light blue-dashed line); 3. a simple VAR without any exogenous variable representing global factors (green-solid line). For the four models, GDP impulse responses to domestic net tax and government spending shocks equal to one percent of GDP are displayed. Sample: 1971:1 - 2009:4.

Appendix A.1: Data used for common factors' estimation.

The data used for the estimation of common factors for non-European Union OECD countries. Data are from OECD and IMF sources, withdrawn through DATASTREAM. Variables are transformed to achieve stationarity. Data transformation codes are: 0 - no transformation; 1 - first difference; 2 - first difference of logarithm; 3 - second difference of logarithm. Data span from 1971:1 to 2009:4.

N.	Country	DS code	Trans.	Variable
				Private consumption
1.	UNITED STATES	USOCFPCND	2	US PRIVATE CONSUMPTION EXPENDITURE (REAL,SA)
2.	CANADA	CNOCFPCND	2	CN PRIVATE CONSUMPTION EXPENDITURE (REAL,SA)
3.	MEXICO	MXOCFPCND	2	MX PRIVATE CONSUMPTION EXPENDITURE (REAL,SA)
4.	NORWAY	NWOCFPCND	2	NW PRIVATE CONSUMPTION EXPENDITURE (REAL,SA)
5.	JAPAN	JPOCFPCND	2	JP PRIVATE CONSUMPTION EXPENDITURE (REAL,SA)
6.	AUSTRALIA	AUOCFPCND	2	AU PRIVATE CONSUMPTION EXPENDITURE (REAL,SA)
7.	NEW ZEALAND	NZOCFPCND	2	NZ PRIVATE CONSUMPTION EXPENDITURE (REAL,SA)
				Private investment
8.	UNITED STATES	USOCFPIND	2	US PRIV. FIXED INV. EXCL.STOCKBUILDING IN REAL TERMS (SA)
9.	CANADA	CNOCFPIND	2	CN PRIV. FIXED INV. EXCL.STOCKBUILDING IN REAL TERMS (SA)
10.	NORWAY	NWOCFPIND	2	NW PRIV. FIXED INV. EXCL.STOCKBUILDING IN REAL TERMS (SA)
11.	JAPAN	JPOCFPIND	2	JP PRIV. FIXED INV. EXCL.STOCKBUILDING IN REAL TERMS (SA)
12.	AUSTRALIA	AUOCFPIND	2	AU PRIV. FIXED INV. EXCL.STOCKBUILDING IN REAL TERMS (SA)
13.	NEW ZEALAND	NZOCFPIND	2	NZ PRIV. FIXED INV. EXCL.STOCKBUILDING IN REAL TERMS (SA)
				Industrial production
14.	UNITED STATES	USQ66..CE	2	US INDUSTRIAL PRODUCTION (SA)
15.	CANADA	CNQ66..CE	2	CN INDUSTRIAL PRODUCTION (SA)
16.	NORWAY	NWQ66..CE	2	NW INDUSTRIAL PRODUCTION (SA)
17.	JAPAN	JPQ66..CE	2	JP INDUSTRIAL PRODUCTION (SA)
18.	AUSTRALIA	AUQ66..CE	2	AU INDUSTRIAL PRODUCTION (SA)
				Stocks
19.	UNITES STATES	USOEXP10D	0	US INCREASE IN STOCKS (SA)
20.	CANADA	CNOEXP10D	0	CN INCREASE IN STOCKS (SA)
21.	AUSTRALIA	AUOEXP10D	0	AU INCREASE IN STOCKS (SA)
				Hours
22.	UNITED STATES	USOCFHRBO	2	US AVERAGE HOURS WORKED,PER EMPLOYEE-BUS.SECTOR(SA)
23.	CANADA	CNOCFHRBO	2	CN AVERAGE HOURS WORKED,PER EMPLOYEE-BUS.SECTOR(SA)
24.	NORWAY	NWOCFHRBO	2	NW AVERAGE HOURS WORKED,PER EMPLOYEE-BUS.SECTOR(SA)
25.	JAPAN	JPOCFHRBO	2	JP AVERAGE HOURS WORKED,PER EMPLOYEE-BUS.SECTOR(SA)
26.	AUSTRALIA	AUOCFHRBO	2	AU AVERAGE HOURS WORKED,PER EMPLOYEE-BUS.SECTOR(SA)
27.	NEW ZEALAND	NZOCFHRBO	2	NZ AVERAGE HOURS WORKED,PER EMPLOYEE-BUS.SECTOR(SA)
				Unemployment
28.	UNITED STATES	USOCFUNRQ	1	US UNEMPLOYMENT RATE (SA)
29.	CANADA	CNOCFUNRQ	1	CN UNEMPLOYMENT RATE (SA)
30.	JAPAN	JPOCFUNRQ	1	JP UNEMPLOYMENT RATE (SA)
31.	AUSTRALIA	AUOCFUNRQ	1	AU UNEMPLOYMENT RATE (SA)
				Labor costs
32.	UNITED STATES	USOCFRCMG	2	US COMPENSATION PER EMPLOYEE (REAL,SA)
33.	CANADA	CNOCFRCMG	2	CN COMPENSATION PER EMPLOYEE (REAL,SA)
34.	JAPAN	JPOCFRCMG	2	JP COMPENSATION PER EMPLOYEE (REAL,SA)
35.	AUSTRALIA	AUOCFRCMG	2	AU COMPENSATION PER EMPLOYEE (REAL,SA)
36.	NEW ZEALAND	NZOCFRCMG	2	NZ COMPENSATION PER EMPLOYEE (REAL,SA)
				Government
37.	UNITES STATES	USOCFNL%Q	0	US GOVERNMENT NET LENDING AS % OF GDP (SA)
38.	CANADA	CNOCFNL%Q	0	CN GOVERNMENT NET LENDING AS % OF GDP (SA)
39.	JAPAN	JPOCFNL%Q	0	JP GOVERNMENT NET LENDING AS % OF GDP (SA)
40.	AUSTRALIA	AUOCFNL%Q	0	AU GOVERNMENT NET LENDING AS % OF GDP (SA)
				Prices

41.	UNITES STATES	USOCFCPIE	3	US CONSUMER PRICE INDEX (SA)
42.	CANADA	CNOCFCPIE	3	CN CONSUMER PRICE INDEX (SA)
43.	MEXICO	MXOCFCPIE	3	MX CONSUMER PRICE INDEX (SA)
44.	NORWAY	NWOCFCPIE	3	NW CONSUMER PRICE INDEX (SA)
45.	JAPAN	JPOCFCPIE	3	JP CONSUMER PRICE INDEX (SA)
46.	AUSTRALIA	AUOCFCPIE	3	AU CONSUMER PRICE INDEX (SA)
47.	NEW ZEALAND	NZOCFCPIE	3	NZ CONSUMER PRICE INDEX (SA)
				Interest rates
48.	UNITES STATES	USQ60B..	0	US MONEY MARKET RATE (FEDERAL FUNDS)
49.	UNITES STATES	FRTBS3M	0	US TREASURY BILL 2ND MARKET 3 MONTH - MIDDLE RATE
50.	UNITES STATES	FRTBS6M	0	US TREASURY BILL 2ND MARKET 6 MONTH - MIDDLE RATE
				Stock Prices
51.	UNITES STATES	DJCMP65	2	DOW JONES COMPOSITE - PRICE INDEX

Appendix A.2: Data description (endogenous variables)

The variables used in the VAR (US) and FAVAR (Germany and UK) models have been constructed based on quarterly series provided by the OECD Economic Outlook, and refer to the general government.[38]

In particular, if we label N the nominal net receipts, G the nominal government spending, GDP the nominal gross domestic product, $DEFL$ the GDP deflator, CPI the consumer price index, POP the total population; the endogenous variables used are defined as follows ("*code*" refers to the taxonomy used in the OECD Economic Outlook Database Inventory):

- n: real per capita net receipts.

$$n = \frac{N}{POP \times DEFL} \tag{A.2.1}$$

where,

∘ $N =$ current receipts ($code : YRG$) - current transfers by the government;

∘ $YRG =$ direct taxes ($code : TY$) $+$ indirect taxes ($code : TIND$) $+$ non-tax receipts;

∘ Direct taxes $=$ direct taxes on business received by the government ($code : TFYB$) $+$ direct taxes on households received by the government ($code : TFYH$);

[38] German data for the pre-1991:1 period refer to Western Germany only.

∘ Current transfers by the government = subsidies ($code: TSUB$) + social security benefits paid by the government ($code: SSPG$).

- g: real per capita government spending.

$$g = \frac{G}{POP \times DEFL} \tag{A.2.2}$$

where,
∘ G = government final consumption expenditure ($code: CG$) + government fixed capital formation ($code: IG$).

- y: real per capita GDP.

$$y = \frac{GDP}{POP \times DEFL} \tag{A.2.3}$$

- p: GDP deflator inflation.

$$p_t = \frac{(DEFL_t - DEFL_{(t-4)}) \times 100}{DEFL_{(t-4)}} \tag{A.2.4}$$

- i: 10-years nominal interest rate on government bonds ($code: IRL$).

- er: real effective exchange rate (volume) ($code: EXCHER$).

- Private investment (Germany): it is computed as total investment minus government investment. Data are from the OECD Economic Outlook.

Appendix A.3: Construction of output and price elasticities of net taxes[39]

The construction of elasticities is conceptually identical to what proposed by Perotti (2005), based on the works by Giorno, Richardson, Roseveare and van den Noord (1995) and Van den Noord (2000). The only notable differences are that we use country-specific output elasticities of indirect taxes instead of assuming them homogeneously equal to one. Moreover, we compute directly output elasticities of transfers without fixing them to -0.2 for all countries. Then, any possible difference between estimates of elasticities in this work and those in Perotti (2005) may

[39] Matlab codes are available from the authors.

arise only due to these (minor) discrepancies or, more importantly, to the estimation sample used (and, for the case of Germany, to the inclusion of the post-unification).

Construction of α_{ny}

Recalling that the net tax variable is derived by subtracting transfers from current receipts, the elasticties of each component in these two aggregates are computed and then averaged taking into consideration their relative weights. Notably:

- Output elasticities of income taxes on households and social securities contributions are computed following equations (B.1) to (B.3) in Perotti (2005);
- Output elasticity of indirect taxes is fixed at 0.95, 1.10 and 0.94 for Germany, the UK and the US respectively (see Van den Noord (2000) Table A.9);
- Output elasticities of corporate income taxes is set equal to zero for Germany and the UK, since in these two countries tax collection lags seem to be important. For the US, instead, we regress log corporate profits on lags 0 to 4 of log GDP and we use the estimated coefficient at lag zero as a proxy for the elasticity;
- Output elasticities of subsidies and social security benefits, excluding unemployment benefits, are set equal to zero since there is no reasons to assume that they respond automatically to changes in output. In contrast, unemployment benefits are assumed to respond fully to output fluctuations within the same quarter. Output elasticities of transfer are then derived by aggregating these two terms (zero and one), after weighting them for their relative importance.

The weighted average of these "item-specific" elasticities gives a value for α_{ny} of 1.38 for Germany, 1.33 for the UK and 1.41 for the US.

Construction of α_{np}

- Price elasticities of income taxes on households and social security contributions are obtained from the OECD (Van den Noord (2000));
- Price elasticities of corporate income taxes and indirect taxes are set equal to zero;

- Price elasticities of transfers are set equal to -1 since, although social expenditures are often indexed to inflation, revisions generally do not occur within the same quarter.

Final estimates of α_{np} are based on weighted averages of these elasticities. In particular, we get 1.05, 0.93 and 1.16 for Germany, the UK and the US respectively.

Appendix A.4: Additional results

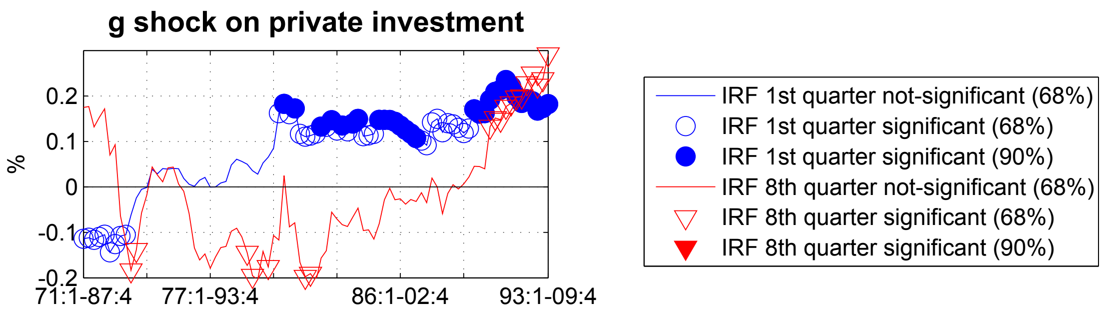

Figure A.4.1: Germany. Effects of a shock to government spending (g) equal to one percent of German GDP on German private investment. The chart reports impulse response functions estimated over 17-years rolling samples of data. Blue lines are short-term multipliers (one quarter IRFs), red lines the two years multipliers (8 quarters IRFs). Filled markers indicate 90% significance, empty markers 68% significance over the corresponding data window.