What are the Effects of Fiscal Policy Shocks ? *

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Abstract

We investigate the effects of fiscal policy surprises for US data, using vector autoregressions. We overcome the difficulties, that changes in fiscal policy may manifest themselves in variables other than fiscal variables first and that fiscal variables may respond "automatically" to business cycle conditions. We do so by using sign restrictions on the impulse responses as method of identification, extending Uhlig (1997), and by imposing orthogonality to business cycle shocks and monetary policy shocks. We analyze three types of fiscal shocks: a deficit financed spending increase, a balanced budget spending increase and a revenue shock, in which revenues increase but government spending stays unchanged. We find that controlling for the business cycle shock is important, but controlling for the monetary policy shock is not, that government spending shocks crowd out both residential and non-residential investment but do not reduce consumption, that a deficit spending cut stimulates the economy for the first 4 quarters but has a low median multiplier of 0.5, and that a balanced budget spending shock and a revenue shock have a contractionary effect on output, consumption and investment. Our results differ from the benchmark of Ricardian equivalence or the benchmark of tax smoothing, and are more in line with theories which allow for intergenerational redistribution. The best fiscal policy for stimulating the economy appears to be a deficit-financed tax cut.

1   Introduction

What are the effects of tax cuts on the economy? And how much does it matter, whether they are financed by corresponding cuts of expenditure or by corresponding increases in government debt, compared to the no-tax-cut scenario? These questions are of key importance to the science of economics and the practice of policy alike. This paper aims at answering these questions by proposing and applying a new method of identifying fiscal policy surprises in vector autoregressions.

Modern macroeconomics views the economy as a dynamic, stochastic system, which can be understood by analyzing the responses to present and past random shocks. Vector autoregressions are well suited for this perspective as an empirical tool. A large literature has therefore successfully applied vector autoregressions in particular to analyze the effects of monetary policy shocks, see e.g. Leeper Sims and Zha (1996), Christiano Eichenbaum and Evans (1997) or Favero (2001) for excellent surveys.

By contrast, the literature on applying vector autoregressions to analyze the effects fiscal policy is rather thin. The topic has received attention only rather recently, most notably by Blanchard and Perotti (1999), Fatas and Mihov (2001a,b) and Favero (2002). Progress in this area has largely been thwarted by three problems. First and perhaps most importantly, fiscal policy surprises may not show up in fiscal variables first. Fiscal policy changes are often preceeded by lengthy debates in Congress: when the changes takes place, they no longer are a surprise. Likewise, the outcome of the tight Gore-Bush race in 2000 might have changed beliefs about future tax cuts more than the actual tax cuts themselves. Thus, relying on unpredicted movements in fiscal variables alone is likely to miss many of the interesting fiscal policy surprises driving the economy. The second problem is the separation of movements in fiscal variables which are caused by fiscal policy shocks and those which are simply the automatic movements of fiscal variables in response to the business cycle. Finally, while there is agreement that a monetary policy shock entails a surprise rise in interest rates, several competing definitions come to mind for fiscal policy shocks.

This paper confronts these problems directly. To address the third, we identify three benchmark fiscal policy shocks rather than only one. We analyze a deficit-financed fiscal expansion, a balanced-budget fiscal expansion as well as a revenue shock, in which government revenues go up but spending remains unchanged. To address the second problem, we also identify a business cycle shock as well as a monetary policy shock and require the fiscal shock to be orthogonal to them, thereby filtering out the automatic

responses.

Finally, for the first and main problem, we do not rely on a decomposition of contemporaneous cause and effects, but rather identify fiscal policy shocks by observing their consequences several quarters into the future. For example deficit-financed policy shocks are identified by requiring government expenditures to rise but government revenues to stay unchanged during a whole year following the shock, compared to the no-shock scenario. That way, fiscal policy shocks which change government expenditure not immediately, but in the near future, are captured.

We apply this method to US quarterly data, from 1955 to 2000. We find that

- controlling for the business cycle shock is important, but controlling for the monetary policy shock is not, when analyzing the allocative consequences of fiscal policy.

- government spending shocks crowd out both residential and non-residential investment without, however, changing interest rates much,

- deficit spending shocks do not reduce private consumption,

- a deficit spending shock weakly stimulates the economy for the first 4 quarters but has a low median multiplier of approximately 0.5,

- a surprise deficit-financed tax cut is the best fiscal policy to stimulate the economy, as it has a maximum median multiplier of approximately 2.

We note that these results differ from the benchmark of Ricardian equivalence or the benchmark of tax smoothing, as these theories would predict that a marginal change in the financing of a given stream of government expenditures should have no or only second-order effects. A closer match to the data may be expected from theories which analyze the effects of fiscal policy changes from the perspective of intergenerational redistribution and limits to the compensating effects of bequests. Our finding that government spending crowds out both private residential and non-residential investment without changing interest rates much is most consistent with a theoretical view, in which shocks to government spending are (possibly imperfect) substitutes for private investment rather than private consumption.

The paper is comprised of two main sections. Section 2 describes the identification of fiscal shocks. The empirical results are presented in section 3. A conclusion is in section 4. The appendix contains additional detail, in particular on the VAR framework and the sign restriction methodology as well as describing the data sources.

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1.1 Comparison with the literature

The method of identifying policy shocks using sign restrictions on impulse responses has been introduced and been applied to monetary policy shocks in Uhlig (1997). Similarly, Faust (1998) uses sign restrictions, imposing them only at the time of impact however. Canova and De Nicolo (2000) and Canova and Pina (1998) identify shocks using sign restrictions on impulse response correlations. Uhlig's method is extended here by imposing orthogonality to the business cycle shock. The focus of interest in this paper is the response of output, private consumption and private non-residential and residential investment to shocks. We therefore impose no identifying restrictions on the responses of these variables and so, as in Uhlig (1997), the method "agnostic" with respect to these variables.

Our approach differs from and complements Fatas and Mihov (2001a,b) and Favero (2002) in that we do not rely on instantaneous movements in fiscal variables and assumptions about the sluggishness of certain variables to identify fiscal policy shocks. Furthermore, we allow for a variety of fiscal policy shocks, while e.g. Fatas and Mihov (2001a) focusses on shocks to the deficit-to-GDP ratio and Fatas and Mihov (2001b) analyzes shocks to government spending as prototype fiscal policy shocks.

Our method is most sharply differentiated from most of the previous literature in that it relies on macroeconomic time series data alone for shock identification. Previous work on fiscal policy such as Romer and Romer (1994), Ramey and Shapiro (1997), Edelberg, Eichenbaum and Fisher (1998) and Blanchard and Perotti (1999) use additional information such as the timing of wars, detailed institutional information about the tax system and detailed historical study of policy decisions or elections in order to identify fiscal policy shocks from automatic movements in the business cycle. We view this paper as complementary to these approaches. While a more narrative approach can add information, a vector autoregressive approach offers an automatically systematic account of fiscal policy shocks.

Our results agree with some of the findings of these previous studies but disagree with others. As in the studies of Blanchard and Perotti (1999), Ramey and Shapiro (1997), and Edelberg, Eichenbaum and Fisher (1998), we find that increased government spending decreases residential investment. In contrast to these previous studies however, we find that non-residential investment is also crowded out by increased government spending. With regard to output and consumption we find that deficit-financed spending expansions leave GDP and private consumption unchanged after a 4 quarter

lag, while a balanced-budget expansion lowers GDP and private consumption. This contrasts with previous studies which find that output rises and consumption falls in response to an increase in government spending, see Ramey and Shapiro (1997) and Edelberg, Eichenbaum and Fisher (1998). Finally our results agree with Blanchard and Perotti (1999), that revenue shocks have a negative impact on output. Indeed the revenue shock has the strongest impact of all our prototype fiscal policy shocks.

Despite, or possibly because of, the small number of studies employing vector autoregressions, there are a wide variety of other empirical studies investigating the effects of fiscal policy. An excellent survey can be found in Hemming, Kell and Mahfouz (2000), and there is no point in repeating their summary here. We wish to highlight Alesina and Perotti (1995) and Perotti (1999) in particular, who show how the success of a fiscal adjustment depends crucially on the relative importance given to certain expenditure reductions and tax increases. The more weight is given to reducing transfer payments and the less weight to tax increases the greater the chance that the fiscal adjustment will be a success. Likewise, we distinguish between the effects of tax increases versus expenditure reductions when reducing deficits, and find similar results. The methodology of this paper could be extended to an even more disaggregated analysis: e.g. the government expenditure variable could be split into government consumption and government investment. To avoid a plethora of results here, we leave this to future work.

A number of authors have investigated "Non-Keynesian" effects of fiscal contractions or nonlinear effects of fiscal policy, stemming from re-establishing credibility, most notably Giavazzi, Jappelli and Pagano (1990, 1996, 2000). Likewise, Perotti (1999) shows how the effects of a reduction in government expenditure can depend on the state of the economy. He shows that a reduction in government expenditure may not be contractionary if it is seen as re-establishing government solvency. Our identification method relies on assuming positive comovements in real GDP and government revenue to result from shocks other than fiscal policy shocks. While we view this assumption to be reasonable as well as minimalistic for identifying fiscal policy shocks, it also implicitely biases the results against strong Non-Keynesian effects.

2 Identifying Fiscal Policy Shocks

A fiscal policy shock is an unpredicted change in fiscal policy. Unfortunately, there is no such thing as a fiscal policy shock "per se". Fiscal policy encompasses a wide variety

of policies: there is an endless list of types of incomes, for which the tax rules could be changed, or categories of government spending, where changes could occur. In this paper we address the much broader and traditional 'macro'-economic issue of the effects on the aggregate economy of aggregate fiscal variables. Even so there still remain a large set of possible policies, since changes in fiscal policy could be about changing the tax-debt mix for financing a given stream of government expenditures, or about changing the level of expenditures. Each one of the three fiscal variables - expenditures, revenues and deficits - could be held constant when changing fiscal policy, by changing the mix of the other two.

We therefore identify and analyze three prototype fiscal policy shocks: a "revenue shock", where revenues and deficits change, but expenditures are left unchanged, a "deficit spending shock", where an increase in government spending is entirely deficit-financed, and a "balanced budget spending shock", where an increase in government spending is tax-financed. While these three shocks are by no means an exhaustive list of what one might want to consider fiscal policy shocks, they span an interesting and significant subspace of all fiscal policy shocks.

When do these shocks occur? Considering the potentially lengthy debates in Congress about, say, a reduction in tax rates, the change in government revenue is fairly predictable by the time the tax reduction actually takes effect. Forward-looking individuals and firms can adjust their economic choices before that date. While the tax change will happen eventually, the surprise of a change in fiscal policy occurs earlier.

This is a thorny and well-understood difficulty when identifying fiscal policy shocks. Our solution is to find a method which relies less on the instantaneous reactions of fiscal variables as is typically done in traditional VAR identification, but rather exploits the idea that fiscal variables respond to fiscal policy shocks further down the road. More precisely, we employ the sign restriction methodology of Uhlig (1997): we identify fiscal policy shocks by restricting the impulse responses of the fiscal variables to have a particular sign for up to four quarters after the shock.

A further problem is to distinguish genuine fiscal policy shocks from responses of fiscal variables to business cycle movements and monetary policy shocks. We solve this problem by also identifying a business cycle shock and a monetary policy shock and by requiring the fiscal policy shock to be orthogonal to both of them. The business cycle shock is identified in a way that is consistent with both demand and supply side explanations and so we regard it as atheoretical. Furthermore, we choose an expenditure

variable excluding some systematically moving components such as transfer payments, see for example Blanchard (1997) on this.[1]

The restriction that fiscal shocks be orthogonal to the business cycle shock has a large effect on the results. This makes sense. If we would not control for the state of the business cycle, we would end up confusing, for example, an increase in government receipts due to a business cycle upturn with an upturn "caused" by a tax increase. However, the choice of requiring the business cycle shock to be causally prior to the fiscal policy shock requires a defense. We regard it as an additional identifying assumption beyond the sign restriction on the impulse responses of the fiscal variables, and as the most prudent choice. In explaining GDP movements, this assumption leaves as much as possible to the business cycle shock. Whatever is left over is then more plausibly an estimate of the effect of a fiscal policy shock than if we were not or only partially controlling for the business cycle effect. Furthermore, our results are also compatible with a data generating process where fiscal policy shocks are causally prior to business cycle shocks, but do not move output, consumption and investment in the same direction.

2.1 The VAR and Identifying Restrictions

We use a VAR in GDP, private consumption, total government expenditure, total government revenue, private residential investment, private non-residential investment, interest rate, adjusted reserves, the producer price index for crude materials and the GDP deflator. The VAR system consists of these 10 variables at quarterly frequency from 1955 to 2000, has 6 lags, no constant or a time trend, and uses the logarithm for all variables except the interest rate where we have used the level. The chosen approach largely dictates the choice of these variables. GDP, private consumption and private investment are included as the focus of interest. Private consumption is also included because the consumption-GDP ratio has predictive value for GDP, as Cochrane (1994) has shown. We split private investment into residential and non-residential investment as the differential responses of residential versus nonresidential investment to fiscal shocks has attracted attention in the literature, see Ramey and Shapiro (1997). The two fiscal variables allow the identification of fiscal policy shocks. We use revenues rather than tax rates, since it seemed to us to be a more reliable indicator for the fiscal stance: there

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[1]This definition of the government expenditure and revenue variables is described in Appendix B and follows Blanchard and Perotti (1999). We use these definations in order not to obscure the implications of the new identification technique used in this paper, by using different data.

Shocks	Gov. Revenue	Gov. Expend.	GDP, Consumpt., Non-Resid. Investm.	Interest Rate	Adjusted Reserves	Prices
Other Shocks						
Business Cycle	+		+			
Monetary Policy				+	-	-
Fiscal Policy Shocks						
Revenue	+	**0**				
Balanced Budget	+	+				
Deficit Spending	**0**	+				

Table 1: *A "+" means that the impulse response of the variable in question is restricted to be positive for four quarters following the shock, including the quarter of impact. Likewise, a "-" indicates a negative response and a "0" indicates a zero response in the four quarter window. A blank entry indicates, that no restrictions have been imposed.*

are many different types of taxes and tax rates, and the effort in collecting taxes varies. The monetary and price variables are there to identify monetary policy shocks. All the components of national income are in real per capita terms. A more detailed description can be found in appendix B.

An overview for our identifying sign restrictions on impulse responses is provided in table Table 1. A "+" means that the impulse response of the variable in question is restricted to be positive for four quarters following the shock, including the quarter of impact. Likewise, a "-" indicates, that the response is restricted to be negative during the first post-shock year, and a "0" indicates, that the response is exactly zero during these four quarters. A blank entry indicates, that no restrictions have been imposed.

2.2 The identifying assumptions in detail.

A business cycle shock is a shock which jointly moves output, consumption, non-residential investment and government revenue in the same direction. Such a co-movement could have a number of causes, which we do not separate out further here. They could e.g. be due to supply shocks of various kinds, or to demand shocks which drive up consumption as well as investment simultaneously.

The restriction that government revenues increase with output in the business cycle shock should be emphasized. This our crucial identifying assumption for fiscal policy shocks: when output and government revenues move in the same direction, we essentially assume that this must be due to some improvement in the business cycle generating the increase in government revenue, not the other way around. We regard this is a reasonable assumption, and consistent with a number of theoretical views. Furthermore, our identifying assumptions are close to minimalistic: some assumptions are needed to say anything at all. Obviously, the orthogonality assumption a priori excludes the view that positive co-movements of government revenues and output are caused by some form of 'Laffer Curve" of "fiscal consolidation" effect of a surprise rise in taxes.

A monetary policy shock moves interest rates up and reserves and prices down for up to a year after the shock. These identifying restrictions are close to those used in Uhlig (1997). We also require the monetary policy shock to be orthogonal to the business cycle shock. To the extent that a monetary policy shock also moves output, consumption and the two investment variables in the same direction, part of what is captured by the business cycle shock may be due to monetary policy. However this is not a problem for our method since our aim is to control for both shocks rather than to analyze the consequences of monetary policy shocks "per se."

Fiscal policy shocks are identified only through restricting the impulse responses of the fiscal variables and through the requirement that they are orthogonal to business cycle shocks only or to both business cycle shocks as well as monetary policy shocks. The "deficit spending shock" is identified as increasing government spending but leaving government revenues unchanged and the "revenue shock" is identified as increasing government revenue but leaving government expenditures unchanged during the four-quarter window following the shock. The "balanced budget spending shock" is identified by requiring both government revenues and expenditures to increase in such a way that the sum of the weighted increase in revenues and expenditure is zero for each period

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in the four-quarter window following the shock.[2] Since there does not seem to be a consensus theoretical view on what fiscal policy shocks will do, and since the identifying assumptions made here seem sufficient, we decided not to impose further restrictions.

2.3   Making it precise

To implement the identification stated above, one needs to say a bit more. The identification of the fiscal shocks described above involves a combination of zero restrictions (e.g. the impulse response of government revenues to a deficit spending shock should zero for the first 4 quarters) and inequality restrictions. The zero restrictions are imposed exactly and the inequality restrictions are imposed via the minimization of a criterion function. Details on the methodology and terminology are in appendix A, where we also define an impulse vector, introduce the new concept of an impulse matrix, and provide a characterization. In this subsection, we concentrate on the key steps.

The essential idea is as follows. A VAR in reduced form is given by

$$Y_t = \sum_{i=1}^{L} B_i Y_{t-i} + u_t \ , t = 1, ...T, \qquad E[u_t u_t'] = \Sigma$$

where Y_t are $m \times 1$ vectors, L is the lag length of the VAR, B_i are $m \times m$ coefficient matrices and u_t is the one step ahead prediction error. Let $\widetilde{A}$ be the lower triangular Cholesky factor of Σ. We do not use the Cholesky factorization for identification. Appendix A shows that it only serves as a useful computational tool, and any other factorization for these calculations would deliver the same results.

Any shock or impulse vector, a, can be written as, $a = \widetilde{A}q$, where q are the identifying weights which are to be determined and where, $q = [q_1, \ldots, q_m]$, $\parallel q \parallel = 1$. Let $r_a(k)$ be the m dimensional impulse response at horizon k to the impulse vector a. This can be written as

$$r_a(k) = \sum_{i=1}^{m} q_i r_i(k) \qquad (1)$$

see equation (3) in appendix A.

The identifying restriction that the impulse responses of some variable to an impulse vector a for the first four quarters are zero, can be written as the linear restriction

$$0 = Rq$$

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[2]The weights are the average shares in GDP over the sample of the government expenditure and government revenue variables.

where R is a $4 \times m$ matrix, see equations (4) and (5) in appendix A.

To additionally impose the inequality restrictions as well as orthogonality to the business cycle shock, characterized by the weights $q^{(1)}$, say, we proceed as follows. Appendix A defines the penalty function f, defined on the real line. We solve for the weights q and thus $a = \widetilde{A}q$ by solving the minimization problem

$$q = \mathrm{argmin}_{Rq=0,q'q^{(1)}=0}\Psi(\widetilde{A}q) \tag{2}$$

where the criterion function $\Psi(a)$ is given by

$$\Psi(a) = \sum_{j \epsilon J_{S,+}} \sum_{k=0}^{3} f(-\frac{r_{ja}(k)}{s_j}) + \sum_{j \epsilon J_{S,-}} \sum_{k=0}^{3} f(\frac{r_{ja}(k)}{s_j})$$

The criterion function sums penalties over the four periods $k = 0, \ldots 3$ following the shock and over the indices of variables with positive ($J_{S,+}$) and negative ($J_{S,-}$) sign restrictions, respectively. The impulse responses are normalized by the standard error s_j of variable j.

Following Uhlig (1997), we use a Bayesian VAR, taking 100 draws from the posterior, and identifying the shocks for each.

3   Results

The results can be seen in figures 2 through 10, where we have plotted the impulse responses of our 10 variables to the shocks, identified according to the methodology above. Impulse responses are in percent of the variable shown. Shown are the 16th, 50th and 84th quantiles of these impulse responses, calculated at each horizon between 0 and 24 quarters after the shocks. Restrictions are indicated by vertical lines.

3.1   The Business Cycle Shock

Consider first the business cycle shock in figure 2. In response to the business cycle shock, output, consumption, non-residential investment and government revenue increase in the first four quarters by construction. Given that no restriction is placed on these responses after four periods, it is notable that all of these responses are persistent. Government revenues increase approximately twice as much in percentage terms as GDP. There is no contradiction here, provided marginal tax rates are approximately twice average tax

rates. The persistence in the non-residential investment variable indicates that a business cycle shock may increase the steady state capital to labor ratio and so generate a higher level of steady state income, consumption and government revenue. It must be stressed that these responses are consistent with both demand and supply side explanations of the business cycle and this paper is agnostic on the issue of the relative importance and persistence of demand and supply shocks.

The responses of the monetary variables and the government spending variable to the business cycle shock were not restricted at all by the identification method and their responses are quite interesting. The interest rate rises and the adjusted reserves fall in response to a positive business cycle shock. This could be caused by a systematic counter-cyclical response of monetary policy over the sample period, which fits with the description of monetary policy given by Romer and Romer (1994). The fall in adjusted reserves (compared to the no-business-cycle-shock scenario) would indicate that this counter-cyclical response is rather strong.

Government expenditures in contrast do not behave in a counter-cyclical fashion. Rather they increase, slowly, with a positive business cycle shock. Thus if a business cycle boom fills the government's coffers with cash, it will spend more eventually. Note again that, following Blanchard and Perotti (1999), we chose the government expenditure variable to be government consumption and investment in order to isolate changes in government expenditure from automatic changes over the business cycle. Thus the government expenditure variable does not include transfer payments which almost surely would automatically vary counter-cyclically.

3.2 The Monetary Policy Shock

The response to a monetary policy shock is shown in figure 3. Note that we have constructed the monetary policy shock to be orthogonal to the business cycle shock shown in figure 2. Thus this shock represents that part of the unanticipated quarterly change in monetary policy that is not accounted for by systematic responses over the quarter to unanticipated business cycle shocks. A consequence of our identification strategy is that if monetary policy shocks should be such that surprise rises in the interest rate cause increases in output, consumption and investment, then these effects would be captured by the business cycle shock shown in the figure 2, not by the monetary shock shown here. Thus, output, consumption and investment have to fall almost by construction in figure 3, and they do, although interestingly by very little. The main purpose of

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characterizing the business cycle and monetary shocks is to filter out the effects of these shocks on the fiscal variables: the additional orthogonalization among these two shocks has no effect on that.

The results here are consistent with the conventional view that the surprise rise in the interest rate leads to reductions in output, investment and consumption. The results are also not inconsistent with the findings in Uhlig (1997): there, without orthogonality to the business cycle shock, sign restriction methods do not deliver a clear direction for real GDP in response to a surprise rise in interest rates. What is a little surprising is the 1 percent rise in government revenue in response to a half percent rise in interest rates. A plausible explanation is that over the sample period, monetary and fiscal policy was coordinated so that a monetary tightening was accompanied by a fiscal tightening via an increase in taxes as well. However this is not the only interpretation, it is also conceivable that the increase in revenue comes from various forms of capital income taxation via induced portfolio shifts.

3.3 The Revenue Shock

A revenue shock is identified as increasing government revenue but leaving government expenditures unchanged during the four-quarter window following the shock. The responses of a revenue shock differ markedly depending on whether it is restricted to be orthogonal to the business cycle or not.

In figure 4, the revenue shock is identified without any orthogonality restrictions. Here, real GDP, consumption, investment as well as interest rates increase in response to a revenue increase. Thus if one was to draw a lesson from these responses, one would conclude that raising taxes in order to lower deficits is one way to stimulate the economy. We find it more plausible that this result is due to reverse causality i.e. government revenue is rising because of a boom, rather than the other way around and that this identification of the fiscal policy shock is not appropriate. Thus what we see in figure 4 is more plausibly some version of a business cycle shock rather than a surprise change in fiscal policy.

In figure 5 the revenue shock is restricted to be orthogonal to the business cycle shock. Now, the responses look reasonable. GDP, consumption and residential investment fall in response to an increase in revenue although interestingly, nonresidential investment rises somewhat before falling.

It is a bit hard to understand why interest rates should rise, though. After all,

if the additional tax revenues are used for paying down the debt, one would expect falling, rather than rising interest rates. A possible interpretation for these responses is policy coordination and a joint belt tightening by both the fiscal as well as the monetary authorities. If so, the issue arises as to whether it is the monetary authority or the fiscal authority, which is responsible for "kicking off" such a phase of higher prudence.

With this or with any other interpretation, one may suspect, that the rise in interest rates is due to a confusion of fiscal policy shocks with monetary policy shocks. If so, 6 provides the right answer: there, the revenue shock is restricted to be orthogonal to both the business cycle shock and the monetary policy shock. A hike in interest rates due to a monetary policy shock has an initially somewhat depressing effect on output, according to our results above: thus, taking these two responses out of the response to a revenue increase when ordering the revenue shock third might be expected to lead to a more expansionary result.

Surprisingly, we find that there is practically no difference to figure 5 regarding GDP, consumption and investment. There are some small differences in the response of monetary variables, i.e. reserves, interest rates, and prices: their responses are now smaller and often insignificant, when ordering the fiscal shock third. We conclude from this, that controlling for the business cycle shock is important, but controlling for the monetary policy shock is not, when analyzing the allocative consequences of fiscal policy. Below, we shall investigate and confirm this hypothesis also for the other fiscal shocks.

We note that our results differ from a theoretical analysis based on Ricardian neutrality or optimal tax smoothing, as these theories would predict that a marginal change in the financing of a given stream of government expenditures should have no or only second-order effects. A closer match to the data may be expected from theories which analyze the effects of fiscal policy changes from the perspective of intergenerational redistribution and limits to the compensating effects of bequests.

3.4   The Deficit-Spending Shock

A deficit spending shock is identified as increasing government spending but leaving government revenues unchanged during the four-quarter window following the shock. Figure 7 shows the responses when orthogonality to the business cycle shock is imposed while orthogonality to both business cycle shocks and monetary policy shocks is imposed for figure 8. Again, the difference between the responses in figures 7 and 8, is small. The biggest difference again being the response of monetary variables, which are smaller

and often insignificant.

Figure 8 shows that a deficit spending shock stimulates output for the first four quarters although only weakly, see subsection 3.6. The deficit spending shock does not cause private consumption to change. It does reduce residential and non-residential investment, although interestingly not via higher interest rates. These responses are hard to reconcile with theories in which government expenditures is a substitute for private consumption, but easier to reconcile with the position that the shocked part of government expenditures are (possibly imperfect) substitutes for private investment. For example an increase in investment in public sector housing may reduce private investment in rentable housing. Total wealth stays unchanged, and it may thus be optimal to leave consumption unchanged.

The response of prices to a deficit spending shock is a little puzzling, in particular, since it does not go away with controlling for the monetary policy shock. Both the GDP deflator and the producer price index for crude materials show a decline in response to a deficit spending shock. This does not sit well either with standard textbook Keynesian AS/AD models, where an increase in demand increases the price level, or with the recent fiscal theory of the price level, in which an increase in public debt is associated with an increase in the current or future price level, see for example Sims (1994). A possible explanation for this is again the imperfect substitutability of public and private sector investment. In the example of public and private sector housing investment, if the public investment offered lower priced housing than the private sector alternative, then the GDP deflator would fall. This lower price may be due to the lower profits from or lower quality of publicly provided housing.

3.5 The Balanced Budget Spending Shock

The balanced budget spending shock is identified by requiring both government revenues and expenditures to increase in such a way that the sum of the weighted increase in revenues and expenditure is zero for each period in the four-quarter window following the shock.[3] The results are in figure 9, when assuming only orthogonality to the business cycle shock, and in figure 10, when assuming orthogonality both to the business cycle shock and the monetary policy shock. Again the difference between the responses in figures 9 and 10, are small with the biggest difference being in the response of monetary

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[3]The weights are the average shares in GDP over the sample of the government expenditure and government revenue variables.

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variables.

The balanced-budget increase has a somewhat depressing effect on the economy, in contrast to the deficit-spending shock which leaves GDP and consumption fairly unchanged. One can think of a balanced-budget shock roughly as a deficit-spending shock plus a revenue shock, so in light of the results for the other two fiscal shocks above, the results here should not surprise. As with the deficit spending shock both residential and non-residential investment decrease and again this decrease in investment does not work through the channel of higher interest rates. The GDP deflator decreases slowly, again consistent with the interpretation of imperfect substitutability of public and private investment outlined above.

3.6 Multipliers

The impulse responses in figures 4 through 10 give an indication of the size of the multipliers associated with each fiscal shock. However as the scale of these figures differ across shocks for some variables we place some descriptive statistics below in Table 2. We also use information not in the impulse response figures to discuss the standard errors of these figures. To do this we calculate the maximum and minimum multipliers of output in the first 24 quarters after each shock. The statistics for the median of these maximum and minimum responses of output are placed in Table 3 along with the 16th, and 84th percentiles which is the confidence interval for this statistic.

Table 2 gives little support for the use of either government spending shocks to stimulate the economy. The multiplier of the median impulse response of the deficit spending shock is quite low. On impact the multiplier is just 0.18, i.e. a $ 1 increase in government spending increases GDP by only 18 cents. If one argues that the benefits of this policy work only after a lag then the maximum output response occurs at lag 3, which implies a multiplier of just 0.5. As figure 10 shows, the balanced budget spending shock is not expansionary at all and its most expansionary effect is on impact with a negative implied multiplier equal to - 0.07. The negative revenue shock in contrast is quite expansionary with a sizeable multiplier of 0.16 initially rising to 1.95 after 9 lags. That is to say a decrease in government revenues of $ 1 initially increases GDP by 16 cents but after 2 1/4 years GDP will be $1.95 higher, holding prices constant.

An important lesson one can draw here is that while a deficit-financed expenditure stimulus is possible, the eventual costs are four times as high as the immediate benefits. For suppose that, first, government spending is increased by two percent of GDP, financed

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Median Responses to Fiscal Shocks						
Fiscal Shock	Initial Response			Maximum Response		
	Fiscal Shock	GDP Response	Implied Initial Multiplier	Fiscal Shock	GDP Response	Implied Maximum Multiplier
Deficit Spending	0.69	0.026	0.18	0.69	0.072 at lag 3	0.50
Balanced Budget	0.46	-0.007	-0.074	0.46	-0.007 at lag 0	-0.074
Negative Revenue Shock	1.21	0.032	0.16	1.21	0.382 at lag 9	1.95

Table 2: *These statistics are taken from the median impulse responses of the fiscal shocks when they are identified third and restricted to be orthogonal to the monetary and business cycle shocks. The multiplier statistic is calculated as follows: multiplier $= \frac{GDP\ response}{Fiscal\ shock}/(Average\ Fiscal\ variable\ share\ of\ GDP)$. This formula implies that the initial multiplier of the deficit spending shock is $\frac{0.026}{0.69}/0.208$, where 0.208 is the average fraction of GDP over the sample of the expenditure variable. We used "government spending" as the fiscal variable for the deficit spending shock and the balanced budget shock, and "government revenue" as the fiscal variable for the revenue shock.*

by increasing the deficit: this results, at maximum, in a one percent increase in GDP. But the increased deficit needs to be repaid eventually with a hike in taxes. Even ignoring compounded interest rates, this would require a tax hike yielding an increase of government revenues by two percent of GDP. Assuming the tax hike to be a surprise, when it occurs, allows us to use the results above. The tax hike results eventually in a four percent drop in GDP, i.e. the overall net result is a fall in GDP of three percent. I.e., the costs are four times as high as the initial benefit in terms of percent changes in GDP. This reasoning is consistent with the balanced budget spending shock. We see below in Table 3 that the minimum multiplier associated with the balanced budget spending has a confidence interval of -1.3 and -6.44.

Obviously, there is a considerable degree of uncertainty in these numbers, as we have simply read the maximum multipliers off the median impulse responses. Standard errors are therefore provided in table 3. Here, for each fiscal shock, and for each of our 100 draws from the posterior, we take the maximum and minimum multipliers of GDP and also record the corresponding lag [4]. We then order these maxima and minima and report the 16th, 50th and 84th percentiles in Table 3.

Table 3 in general supports the conclusions above. The maximum expansionary effect of a deficit spending shock is much below that of the tax cutting negative revenue shock, although the lower bound of the confidence interval for the maximum response is higher than 0.50. Interestingly, while the negative revenue shock's maximum multiplier is significantly positive and its minimum multiplier is insignificantly different from zero, this is not the case for the two spending shocks. For these shocks both the maximum and minimum responses are significant and of differing signs. This is probably due to the increased variance in the impulse responses of these shocks at longer lag lengths. For this reason we also look at the maximum and minimum multipliers of the two spending shocks in the first year after the shock. In this case we get the reasonable result that the maximum multiplier of the deficit spending shock is significantly positive and the minimum multiplier insignificantly different from zero. The balanced budget spending shock is now also supportive of the conclusions above as its maximum multiplier is now insignificantly different from zero but its minimum multiplier is significantly negative.

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[4] The multiplier statistic is calculated in terms of the initial, lag 0, fiscal shock as follows: multiplier $= \frac{\text{GDP response}}{\text{Fiscal shock at Lag 0}}/(\text{Average Fiscal variable share of GDP})$. We use "government spending" as the fiscal variable for the deficit spending shock and the balanced budget shock, and "government revenue" as the fiscal variable for the revenue shock.

Fiscal Shock	Maximum Multiplier (Median)		Minimum Multiplier (Median)	
	Maximum Multiplier (Median)	Confidence Interval 16th,84th Quantiles	Minimum Multiplier (Median)	Confidence Interval 16th,84th Quantiles
Deficit Spending	1.2 at lag 16	2.53, 0.66 lag 10, lag 1	-0.92 at lag 8	-0.16, -2.70 lag 2, lag 25
Balanced Budget	0.87 at lag 7	2.57, 0.25 lag 6, lag 3	-3.46 at lag 25	-1.32, -6.44 lag 13, lag 19
Negative Revenue Shock	2.35 at lag 10	4.17, 1.26 lag 20, lag 5	0.26 at lag 1	1.11, -0.11 lag 23, lag 3
Deficit Spending In First Year	0.727 at lag 1	1.02, 0.463 lag 3, lag 1	- 0.0002 at lag 1	0.0002, -0.0008 lag 3, lag 2
Balanced Budget In First Year	0.36 at lag 1	0.91, -0.07 lag 1, lag 1	-0.85 at lag 3	-0.40, -1.35 lag 4, lag

Maximum and Minimum Multipliers to Fiscal Shocks

Table 3: *These statistics relate to the distribution of the maximum and minimum multiplier effects of each fiscal shock. For each draw the maximum and minimum fiscal multiplier is calculated and the 16th, 50th and 84th percentiles of these results are displayed. The multiplier statistic is calculated in terms of the initial, lag 0, fiscal shock as follows: multiplier = $\frac{GDP\ response}{Fiscal\ shock\ at\ Lag\ 0}$/(Average Fiscal variable share of GDP).*

4 Conclusion

In this paper we have presented a new approach for distinguishing the effects of fiscal policy shocks by adapting the method of Uhlig (1997). This approach imposes very few restrictions on the nature of the fiscal policy shocks and in particular imposes no restrictions on the responses of the key variables of interest - GDP, private consumption, private residential and non-residential investment - to fiscal policy shocks. The paper applied this approach using post war data on the US economy.

We have analyzed three types of shocks: a deficit financed spending increase, a balanced budget spending increase (financed with higher taxes) and a revenue shock, in which revenues increase but government spending stays unchanged. We found that controlling for the business cycle shock is important, but controlling for the monetary policy shock is not, that government spending shocks significantly crowd out both residential and non-residential investment but do not reduce consumption, that a deficit spending cut stimulates the economy for the first 4 quarters but has a very low median multiplier of 0.5, and that a balanced budget spending shock and a revenue shock have a contractionary effect on output,consumption and investment.

Our results differ from the benchmark of Ricardian equivalence or the benchmark of tax smoothing, and are more in line with theories which allow for intergenerational redistribution. Our finding that government spending crowds out both private residential and non-residential investment without changing interest rates much is most consistent with a theoretical view, in which shocks to government spending are (possibly imperfect) substitutes for private investment rather than private consumption.

The best fiscal policy for stimulating the economy appears to be (surprise) deficit-financed tax cuts. We wish to point out that this should not be read as endorsing them. This paper only points out, that deficit-financed surprise tax cuts work as a (possibly short-lived) stimulus to the economy, not, that they are sensible. The resulting higher debt burdens may have long-term consequences which are far worse than the short-term increase in GDP, and surprising the economy may not be good policy in any case. These normative judgements require theoretical models, for which the empirical positive results in this paper can provide a useful starting point.

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APPENDIX

A   VARs and impulse matrices

A VAR in reduced form is given by

$$Y_t = \sum_{i=1}^{L} B_i Y_{t-i} + u_t \ , t = 1, ...T, \quad E[u_t u_t'] = \Sigma$$

where Y_t are $m \times 1$ vectors, L is the lag length of the VAR, B_i are $m \times m$ coefficient matrices and u_t is the one step ahead prediction error.

The problem of identification is to translate the one step ahead prediction errors, u_t, into economically meaningful, or 'fundamental', shocks, v_t. We adopt the common assumptions in the VAR literature that there are m fundamental shocks, which are mutually orthogonal and normalized to be of variance 1. Thus $E[v_t v_t'] = I_m$. Identification of these shocks amounts to identifying a matrix A, such that $u_t = Av_t$ and $AA' = \Sigma$. The jth column of A represents the immediate impact, or impulse vector, of a one standard error innovation to the jth fundamental innovation, which is the jth element of v. The following definition is useful, and new.

Definition 1 *An* **impulse matrix** *of rank n is a $n \times m$ sub-matrix of some $m \times m$ matrix A, such that $AA' = \Sigma$.*

An **impulse vector a** *is an impulse matrix of rank 1, i.e. is a vector $a \in \mathbb{R}^m$ such that there exists some matrix A, where a is a column of A, such that $AA' = \Sigma$.*

One can show that the identification does not depend on the particular matrix A chosen beyond a given impulse matrix, i.e. a given impulse matrix uniquely identifies the fundamental shocks corresponding to it:

Theorem 1 *Suppose that Σ is regular. Let a given impulse matrix $[a^{(1)}, \ldots, a^{(n)}]$ of size n be a submatrix of two $m \times m$ matrices A, $\tilde{A}$ with $AA' = \tilde{A}\tilde{A}' = \Sigma$. Let $v_t = A^{-1}u_t, \tilde{v}_t = \tilde{A}^{-1}u_t$ and let $v_t^{(1)}, \ldots, v_t^{(n)}$ resp. $\tilde{v}_t^{(1)}, \ldots, \tilde{v}_t^{(n)}$ be the entries in v_t resp. $\tilde{v}_t$ corresponding to $a^{(1)}, \ldots, a^{(n)}$, i.e., if e.g. $a^{(1)}$ is the third column of A, then $v_t^{(1)}$ is the third entry of v_t. Then, $v_t^{(i)} = \tilde{v}_t^{(i)}$ for all $i = 1, \ldots, n$.*

Proof: *W.l.o.g., let $[a^{(1)}, \ldots, a^{(n)}]$ be the first n column of A and $\tilde{A}$. If this is e.g. not the case for A and if e.g. $a^{(1)}$ is the third column of A, one can find a permutation*

matrix P so that the given impulse matrix will be the first n columns of $\hat{A} = AP$ with $a^{(1)}$ the first column of $\hat{A}$. Since $PP' = I$, $\hat{A}\hat{A}' = \Sigma$. Furthermore, the first column of P is the vector e_3, which is zero except for a 1 in its third entry: hence the first entry of $\hat{A}^{-1}u_t = P'v_t$ must be the third entry of v_t and thus be $v_t^{(1)}$ corresponding to $a^{(1)}$.

With $[a^{(1)}, \ldots, a^{(n)}]$ as the first n column of A and $\tilde{A}$, let $E_n = [I_n, 0_{n,m}]$. Note that $[v_t^{(1)}, \ldots, v_t^{(n)}]' = E_n A^{-1} u_t$. We need to show that $E_n A^{-1} u_t = E_n \tilde{A}^{-1} u_t$ for all u_t. It suffices to show that $E_n A^{-1} \Sigma = E_n \tilde{A}^{-1} \Sigma$, since Σ is regular. But this follows from

$$
\begin{aligned}
E_n A^{-1} \Sigma &= E_n A^{-1} A A' \\
&= E_n A' \\
&= [a^{(1)}, \ldots, a^{(n)}]' \\
&= E_n \tilde{A}^{-1} \tilde{A} \tilde{A}' \\
&= E_n \tilde{A}^{-1} \Sigma
\end{aligned}
$$

•

In the VAR literature identification usually proceeds by identifying all m fundamental shocks and so characterizing the entire A matrix. This requires imposing $m(m-1)/2$ restrictions on the A matrix. This is done either by assuming a recursive ordering of variables in the VAR, so that a Cholesky decomposition of A can be used, see Sims (1986), or by imposing the $m(m-1)/2$ restrictions via assumed short run structural relationships as in Bernanke (1986) and Blanchard and Watson(1986), via assumed long run structural relationships, as in Blanchard and Quah (1989) or via both assumed short run and long run structural relationships as in Gali (1992).

This paper instead extends the method of Uhlig (1997) and identifies at most three fundamental shocks and so needs to characterize an impulse matrix $[a^{(1)}, a^{(2)}, a^{(3)}]$ of rank 3 rather than all of A. This is accomplished by imposing sign restrictions on the impulse responses. Note that by construction, the covariance between the fundamental shocks $v_t^{(1)}, v_t^{(2)}$ and $v_t^{(3)}$ corresponding to $a^{(1)}, a^{(2)}$ and $a^{(3)}$ is zero, i.e. that these fundamental shocks are orthogonal.

To that end, note that any impulse matrix $[a^{(1)}, \ldots, a^{(n)}]$ can be written as the product $[a^{(1)}, \ldots, a^{(n)}] = \widetilde{A}Q$ of the lower triangular Cholesky factor $\widetilde{A}$ of Σ with an $n \times m$ matrix $Q = [q^{(1)}, \ldots, q^{(n)}]$ of orthonormal rows $q^{(i)}$, i.e. $QQ' = I_n$: this follows from noting that $\widetilde{A}^{-1}A$ must be an orthonormal matrix for any decomposition $AA' = \Sigma$

of Σ. Likewise, Let $a = a^{(s)}$, $s \in \{1, \ldots, n\}$ be one of the columns of the impulse matrix and $q = q^{(s)} = \widetilde{A}^{-1} a^{(s)}$ be the corresponding column of Q: note that $q^{(s)}$ does not depend on the other $a^{(p)}$, $p \neq s$. As in Uhlig (1997), it follows easily that the impulse responses for the impulse vector a can be written as a linear combination of the impulse responses to the Cholesky decomposition of Σ as follows. Define $r_{ji}(k)$ as the impulse response of the jth variable at horizon k to the ith column of $\widetilde{A}$, and the m dimensional column vector $r_i(k)$ as $[r_{1i}(k), ..., r_{mi}(k)]$. Then the m dimensional impulse response $r_a(k)$ at horizon k to the impulse vector $a^{(s)}$ is given by

$$r_a(k) = \sum_{i=1}^{m} q_i r_i(k) \tag{3}$$

(where q_i is the i-th entry of $q = q^{(s)}$), delivering equation (1).

The identifying restriction that the impulse responses of the j-th variable to an impulse vector a for the first four periods are zero, can be written as a restriction on the vector q that

$$0 = Rq \tag{4}$$

where R is a $4 \times m$ matrix of the form

$$R = \begin{bmatrix} r_{j1}(0) & \cdots & r_{jm}(0) \\ \vdots & \ddots & \vdots \\ r_{j1}(3) & \cdots & r_{jm}(3) \end{bmatrix} \tag{5}$$

Define the function f on the real line per $f(x) = 100x$ if $x \geq 0$ and $f(x) = x$ if $x \leq 0$. Let s_j be the the standard error of variable j. Let $J_{S,+}$ be the index set of variables, for which identification of a given shock restricts the impulse response to be positive and let $J_{S,-}$ be the index set of variables, for which identification restricts the impulse response to be negative. To impose the additional identifying inequality sign restrictions beyond the zero restrictions of equation (4), we solve

$$a = \mathrm{argmin}_{a = \widetilde{A}q, Rq=0} \Psi(a) \tag{6}$$

where the criterion function $\Psi(a)$ is given by

$$\Psi(a) = \sum_{j \epsilon J_{S,+}} \sum_{k=0}^{3} f\left(-\frac{r_{ja}(k)}{s_j}\right) + \sum_{j \epsilon J_{S,-}} \sum_{k=0}^{3} f\left(\frac{r_{ja}(k)}{s_j}\right)$$

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Computationally, we implement this minimization, using a simplex algorithm: it is available on many statistical packages as e.g. MATLAB and RATS; for this paper we use the version of the algorithm written in GAUSS by Bo Honore and Ekaterini Kyriazidou, available from http://www.princeton.edu/ honore/.

To identify an impulse matrix $[a^{(1)}, a^{(2)}]$, where the first shock is a business cycle shock and the second shock is a fiscal policy shock, first identify the business cycle shock $a^{(1)} = \widetilde{A}q^{(1)}$ in the manner described above and then identify the second shock $a^{(2)}$ by replacing the minimization problem 6 with

$$a = \mathrm{argmin}_{a=\widetilde{A}q, Rq=0, q'q^{(1)}=0} \Psi(a) \tag{7}$$

i.e. by additionally imposing orthogonality to the first shock. The two restrictions $Rq = 0, q'q^{(1)} = 0$ can jointly be written as

$$0 = \widetilde{R}q \tag{8}$$

where $\widetilde{R}' = [q^{(1)}, R']$. Likewise, if orthogonality to two shocks - the business cycle shock and the monetary policy shock - is required, identify the business cycle shock $a^{(1)} = \widetilde{A}q^{(1)}$ and identify the monetary policy shock $a^{(2)} = \widetilde{A}q^{(2)}$ and solve

$$a = \mathrm{argmin}_{a=\widetilde{A}q, Rq=0, q'q^{(1)}, q'q^{(2)}=0} \Psi(a) \tag{9}$$

Given the above we can now state our identification restrictions more formally. We only provide two: the others follow the same pattern.

Definition 2 *A **business cycle shock impulse vector** is an impulse vector a, that minimizes a criterion function $\Psi(a)$, which penalizes negative impulse responses of GDP, private consumption, nonresidential investment and government revenue at horizons $k = 0, 1, 2,$ and 3.*

Definition 3 *A **revenue shock impulse vector** is an impulse vector a minimizing a criterion function $\Psi(a)$, which penalizes negative impulse responses to the vector a of government revenue at horizons $k = 0, 1, 2,$ and 3 subject to the restriction that the impulse responses to the vector a of government spending are zero at horizons $k = 0, 1, 2,$ and 3.*

For the latter definition, we further distinguish the three cases, given by the three minimization problems (6), (7) and (9), depending on which of the additional orthogonality assumptions to the business cycle shock and the monetary policy shock are imposed.

The computations are performed, using a Bayesian approach as in Uhlig (1997), see also Sims and Zha (1998). We take 100 draws from the posterior. For each draw from the posterior of the VAR coefficients and the variance-covariance matrix Σ, the shocks are identified using the criteria described above. Given this sample of 100 draws for the impulse responses, confidence bands can be plotted.

B   The Data

All the data we use is freely available from the World Wide Web. The data on components of US national income is taken from the *National Income and Product Accounts* (NIPA) which are made publically available by the Bureau of Economic Analysis on their website *http://www.bea.doc.gov/bea/uguide.htm*. The monetary data, - the interest rate, producer commodity price index and adjusted reserves - , is taken from the Federal Reserve Board of St Louis' website *http://www.stls.frb.org/fred/*.

B.1   Definitions of Variables in the VAR

All the components of national income are in real per capita terms and are transformed from their nominal values by dividing them by the gdp deflator (NIPA table 7.1 Row 4) and the population measure (NIPA table 2.1 Row 35). The table and row numbers refers to the organization of the data by the Bureau of Economic Analysis.

GDP: This is NIPA table 1.1 Row 1.

Private Consumption: This is NIPA table 1.1 Row 1.

Total Government Expenditure: This is 'Federal Defense Consumption Expenditures', NIPA table 3.7 Row 4, plus 'Federal Non Defense Consumption Expenditures', NIPA table 3.7 Row 15, plus 'State and Local Consumption Expenditures', NIPA table 3.7 Row 28. plus 'Federal Defense Gross Investment', NIPA table 3.7 Row 11, plus 'Federal Non Defense Gross Investment ', NIPA table 3.7 Row 24, plus 'State and Local Gross Investment', NIPA table 3.7 Row 35.

Total Government Revenue[5]: This is 'Total Government Receipts', NIPA table 3.1 Row 1, minus 'Net Transfers Payments', NIPA table 3.1 Row 8, and 'Net Interest Paid', NIPA table 3.1 Row 11.

Private Residential Investment: This is 'Private Residential Investment, NIPA table 1.1 Row 11.

Private Non-Residential Investment: This is 'Nominal Gross Private Domestic Investment', NIPA table 1.1 Row 6,.minus private residential investment, NIPA table 1.1 Row 11.

Interest Rate: This is the Federal Funds rate which is the series *fedfunds* at the Federal Reserve Board of St Louis' website *http://www.stls.frb.org/fred/*. We take the arithmetic average of the monthly figures for the Federal Funds Rate.

Adjusted Reserves: This is the Adjusted Monetary Base given by the series *adjressl* series at the Federal Reserve Board of St Louis' website *http://www.stls.frb.org/fred/*. We take the arithmetic average of the monthly figures to get a quarterly figure.

PPIC: This the Producer Price Index of Crude Materials given by the series *ppicrm* at the Federal Reserve Board of St Louis' website *http://www.stls.frb.org/fred/*. We take the arithmetic average of the monthly figures to get a quarterly figure.

The GDP Deflator: This is NIPA table 7.1 Row 4.

The VAR system consists of these 10 variables at quarterly frequency from 1955(Q1) to 2000(Q4), has 6 lags, no constant or time trend, and uses the logarithm for all variables except the interest rate where we have used the level.

The fiscal variable are chosen so that they will have different responses to business cycle movements and fiscal policy shocks. The government expenditure variable is chosen so as to exclude expenditures which will vary over the business cycle such as transfer payments, see for example Blanchard (1997) p 600 on this. The government receipts variable should clearly respond positively to a business cycle shock, an increase in output should increase tax receipts and reduce transfer payments.

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[5] This definition follows Blanchard and Perotti (1999) in regarding transfer payments as negative taxes. We use this definition in order not to obscure the implications of the new identification technique used in this paper, by using different data.

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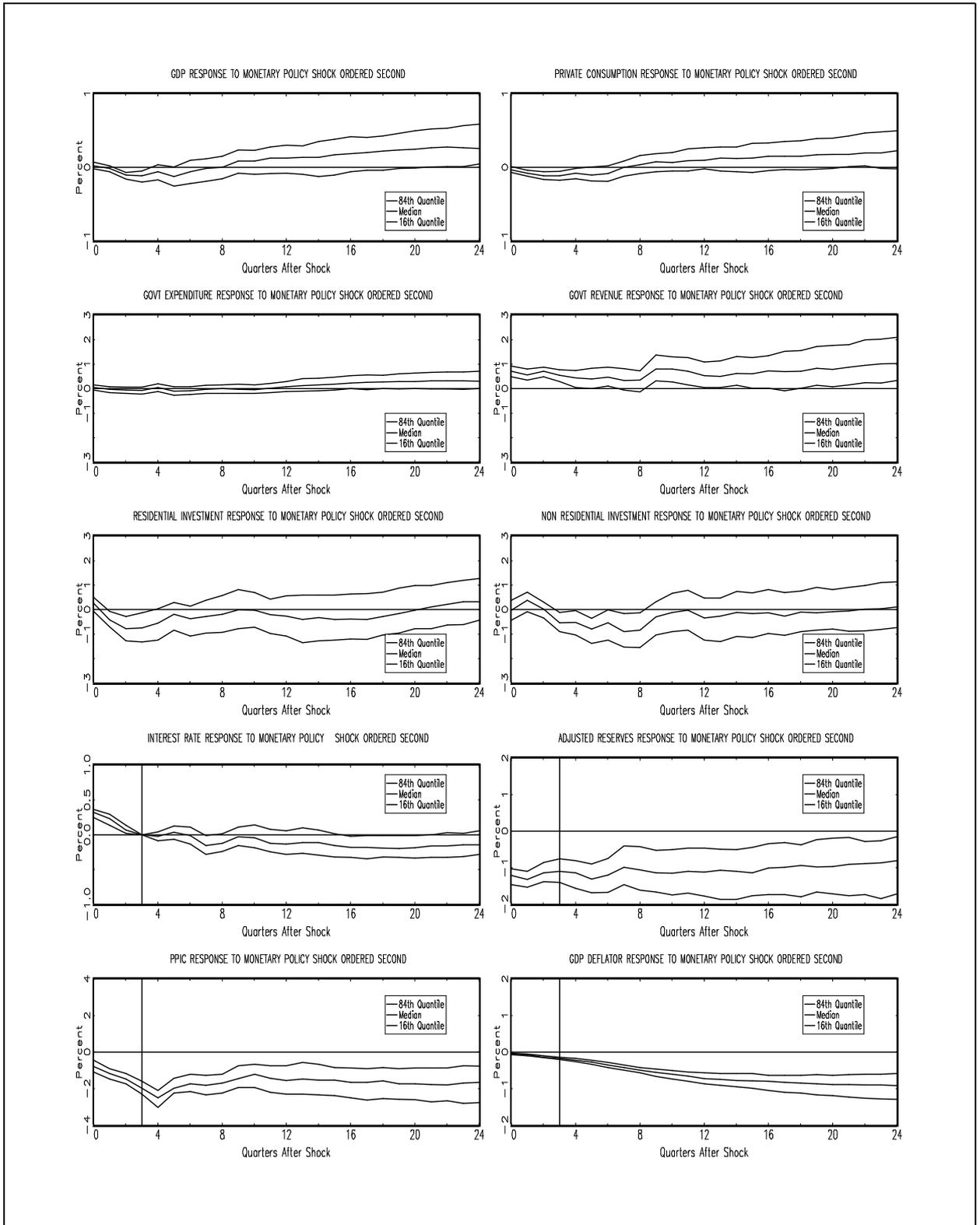
Figures

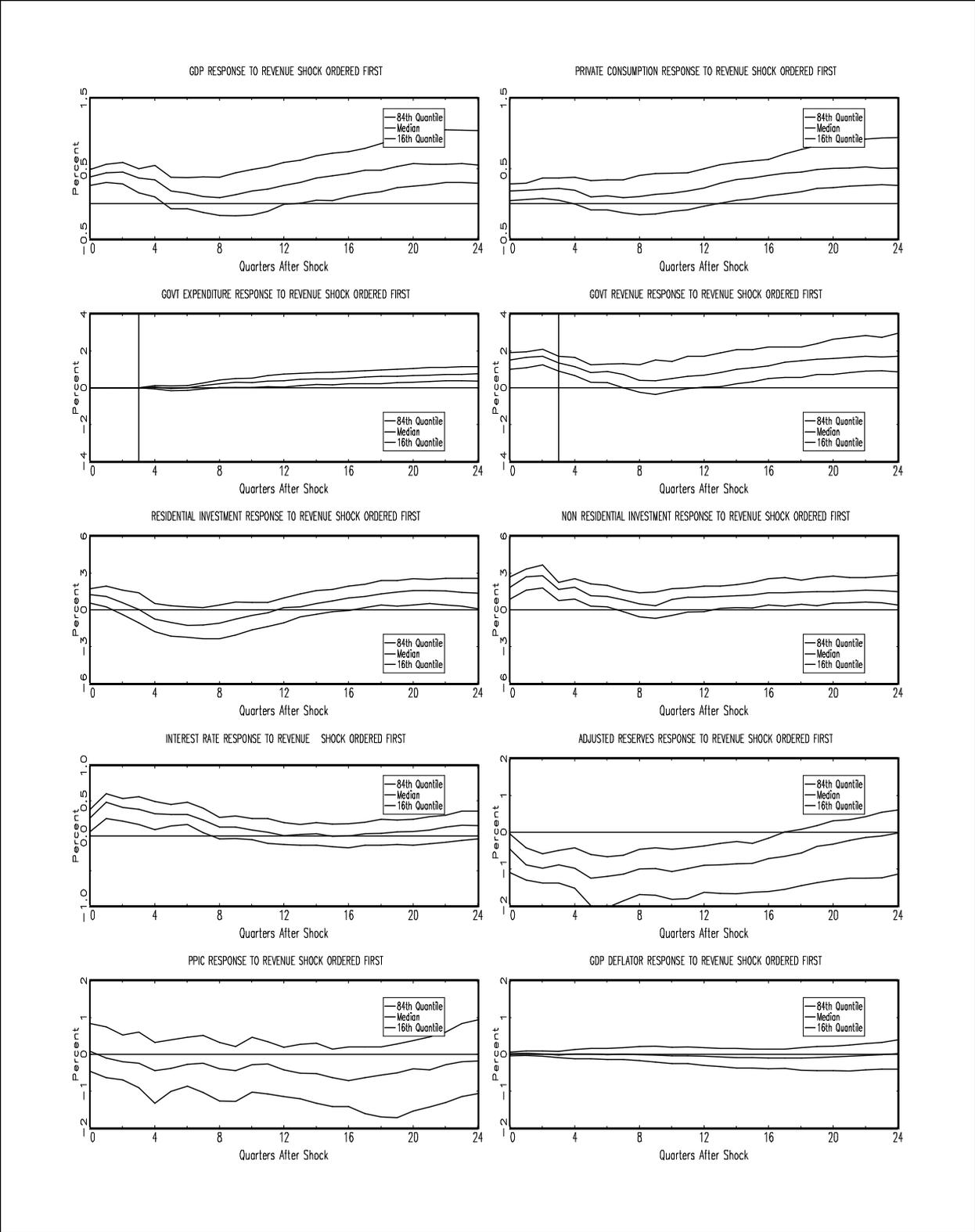|	
Real GDP	Private Consumption
Government Expenditure	Government Revenue
Residential Investment	Nonresidential Investment
Interest Rate	Adjusted Reserves
PPIC	GDP Deflator

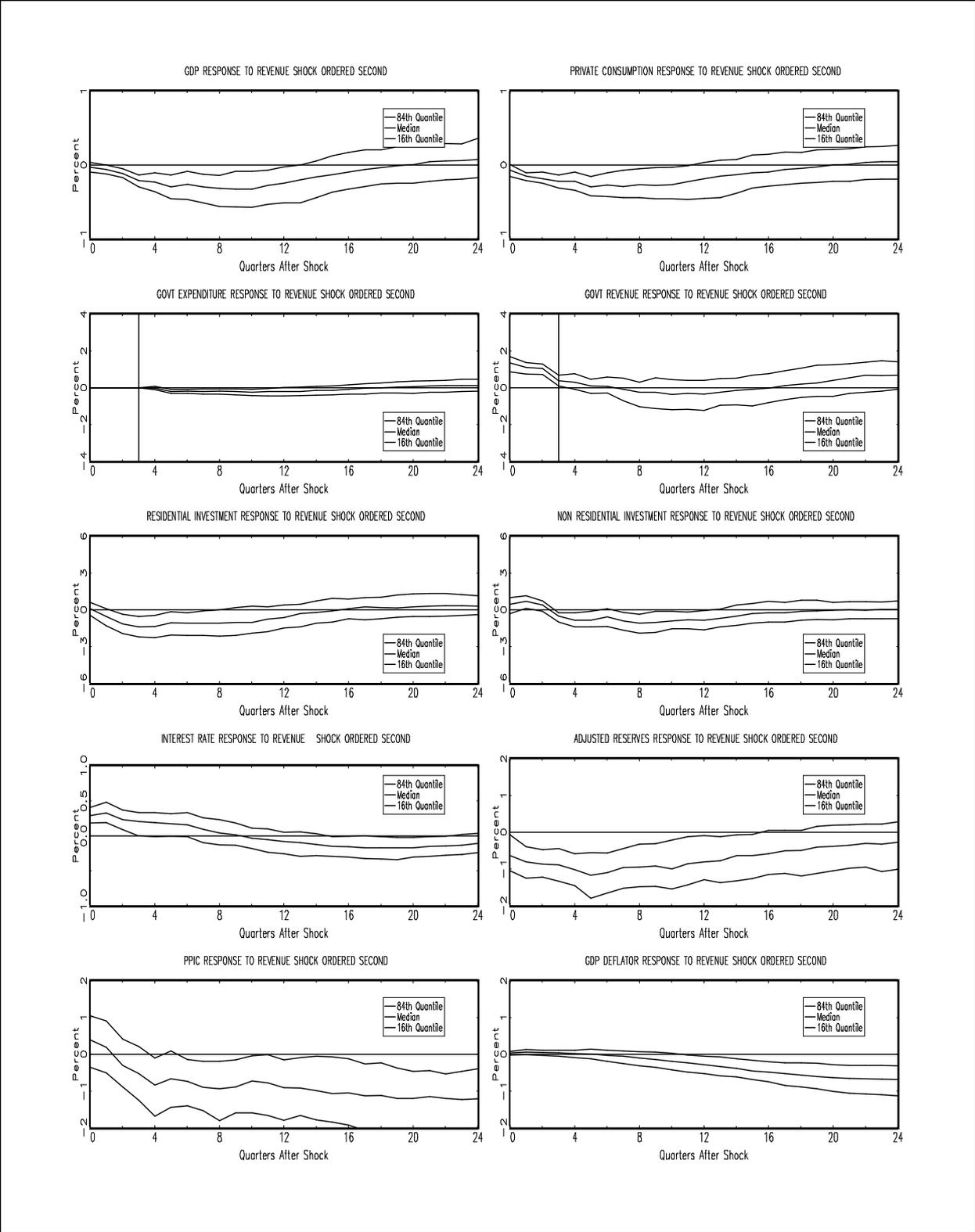Figure 1: *Arrangement of the impulse response panels in the figures.*
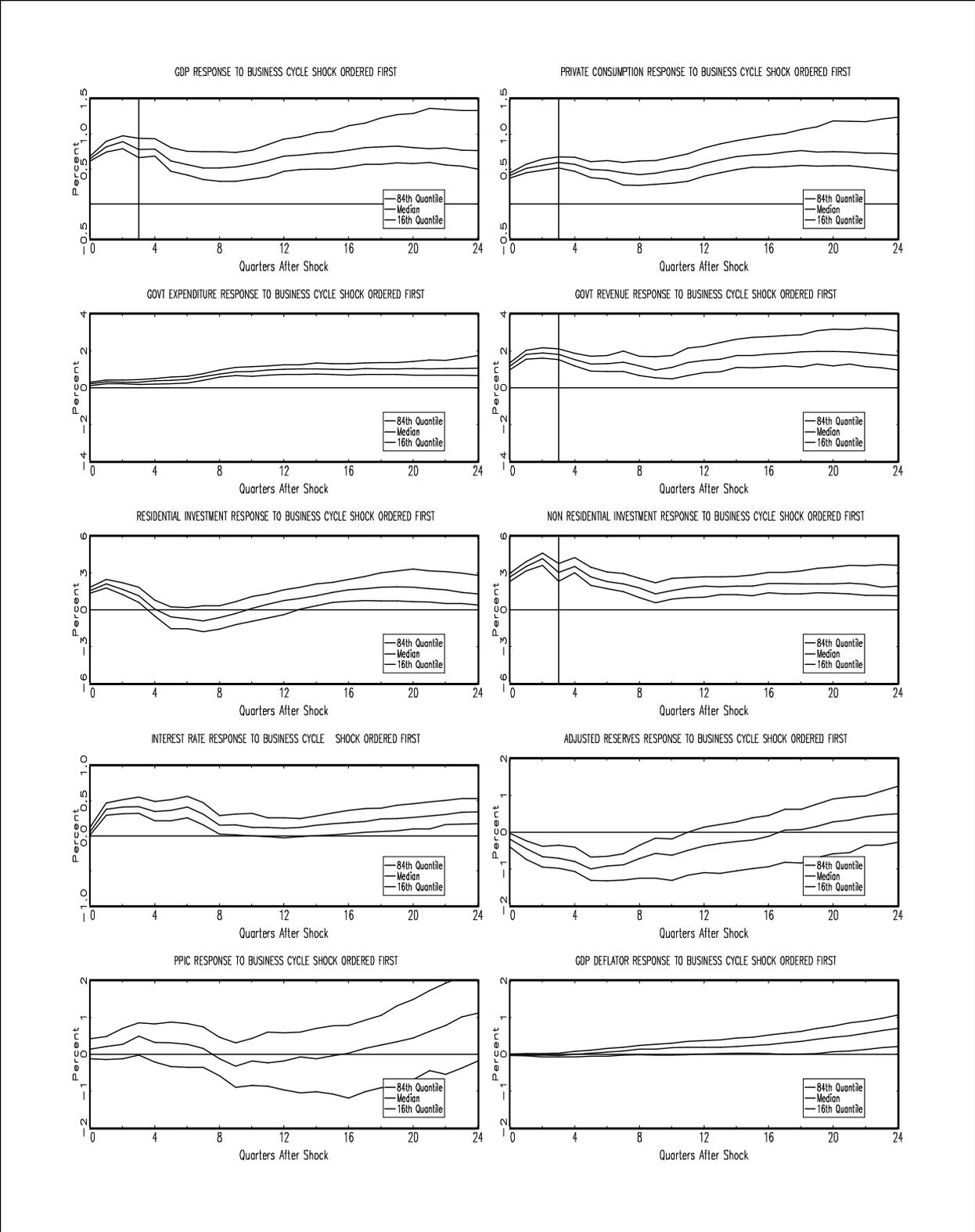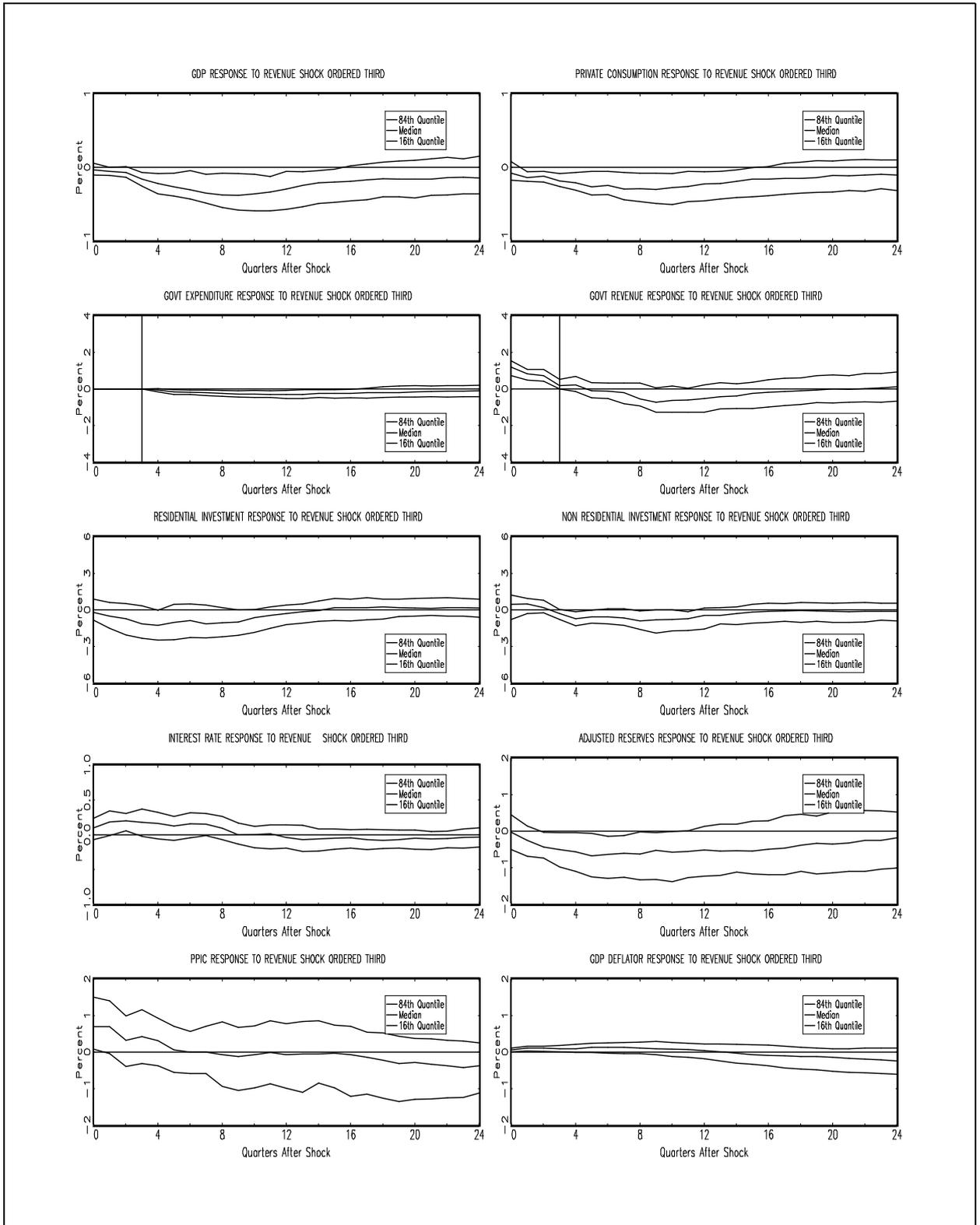
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Figure 2: **The business cycle shock, ordered first.**

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Figure 3: **The monetary policy shock ordered 2nd.**

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Figure 4: **The revenue shock ordered first.**

GDP RESPONSE TO REVENUE SHOCK ORDERED SECOND

PRIVATE CONSUMPTION RESPONSE TO REVENUE SHOCK ORDERED SECOND

GOVT EXPENDITURE RESPONSE TO REVENUE SHOCK ORDERED SECOND

GOVT REVENUE RESPONSE TO REVENUE SHOCK ORDERED SECOND

RESIDENTIAL INVESTMENT RESPONSE TO REVENUE SHOCK ORDERED SECOND

NON RESIDENTIAL INVESTMENT RESPONSE TO REVENUE SHOCK ORDERED SECOND

INTEREST RATE RESPONSE TO REVENUE SHOCK ORDERED SECOND

ADJUSTED RESERVES RESPONSE TO REVENUE SHOCK ORDERED SECOND

PPIC RESPONSE TO REVENUE SHOCK ORDERED SECOND

GDP DEFLATOR RESPONSE TO REVENUE SHOCK ORDERED SECOND

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Figure 5: **The revenue shock ordered 2nd.**

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Figure 6: **The revenue shock ordered 3rd.**
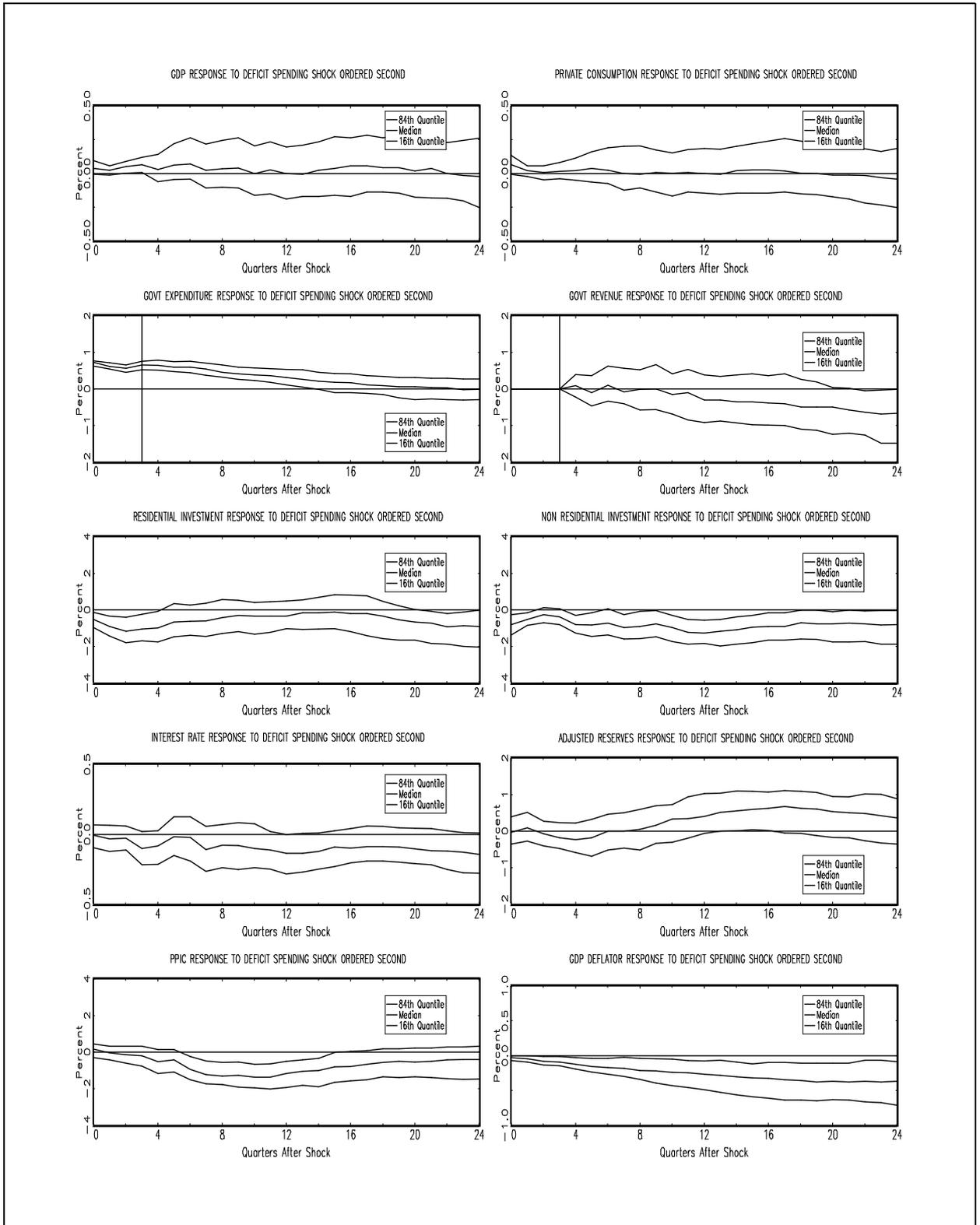
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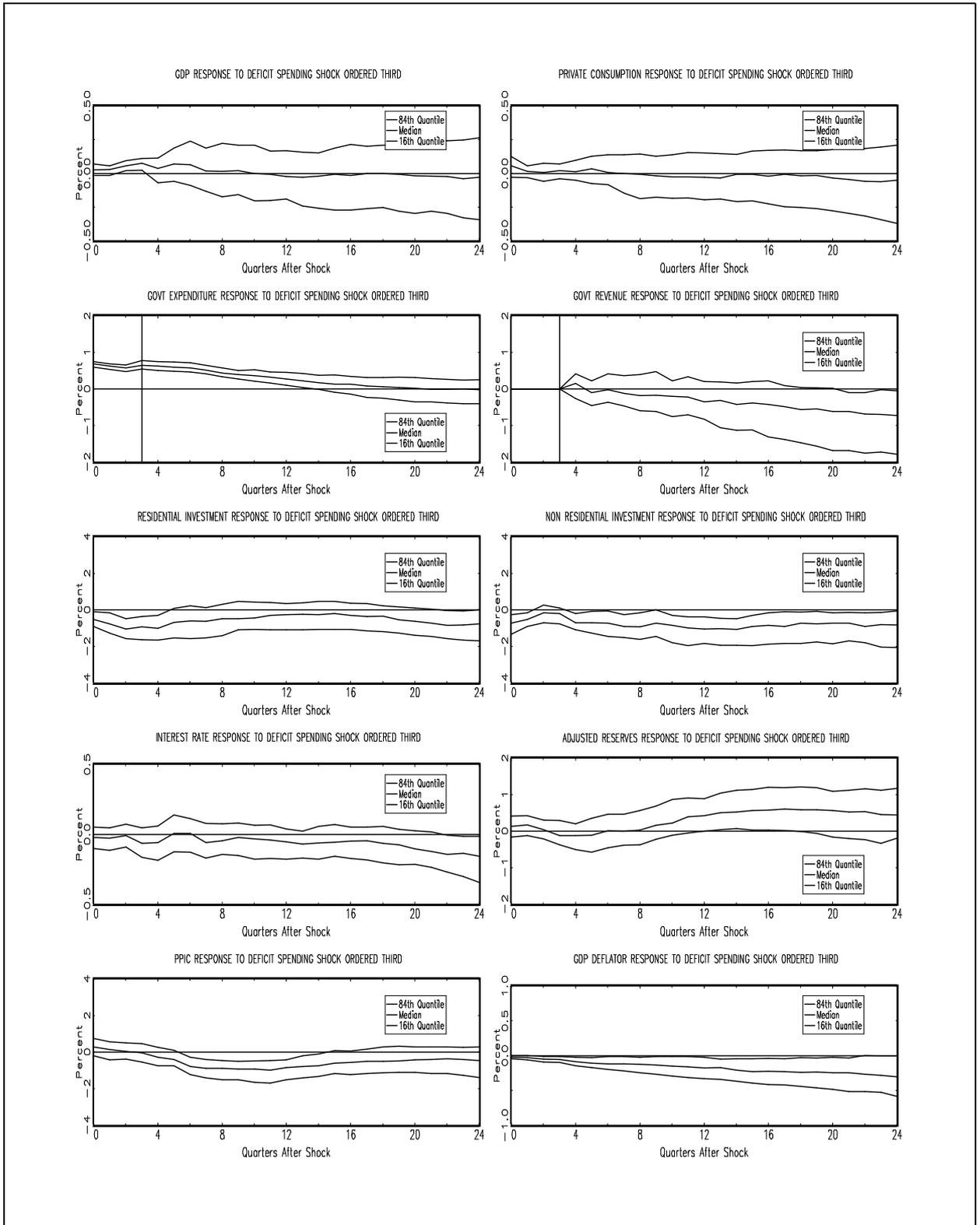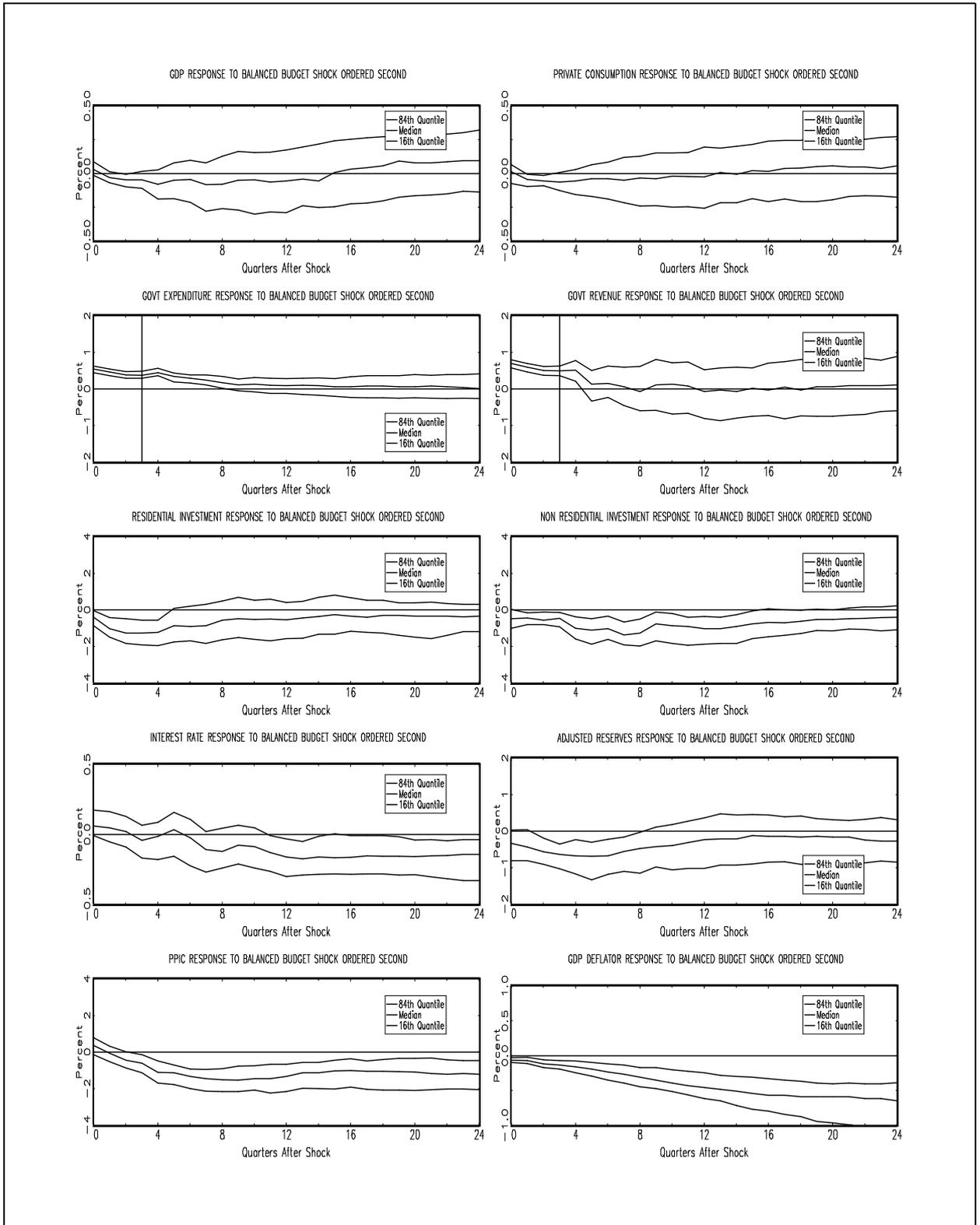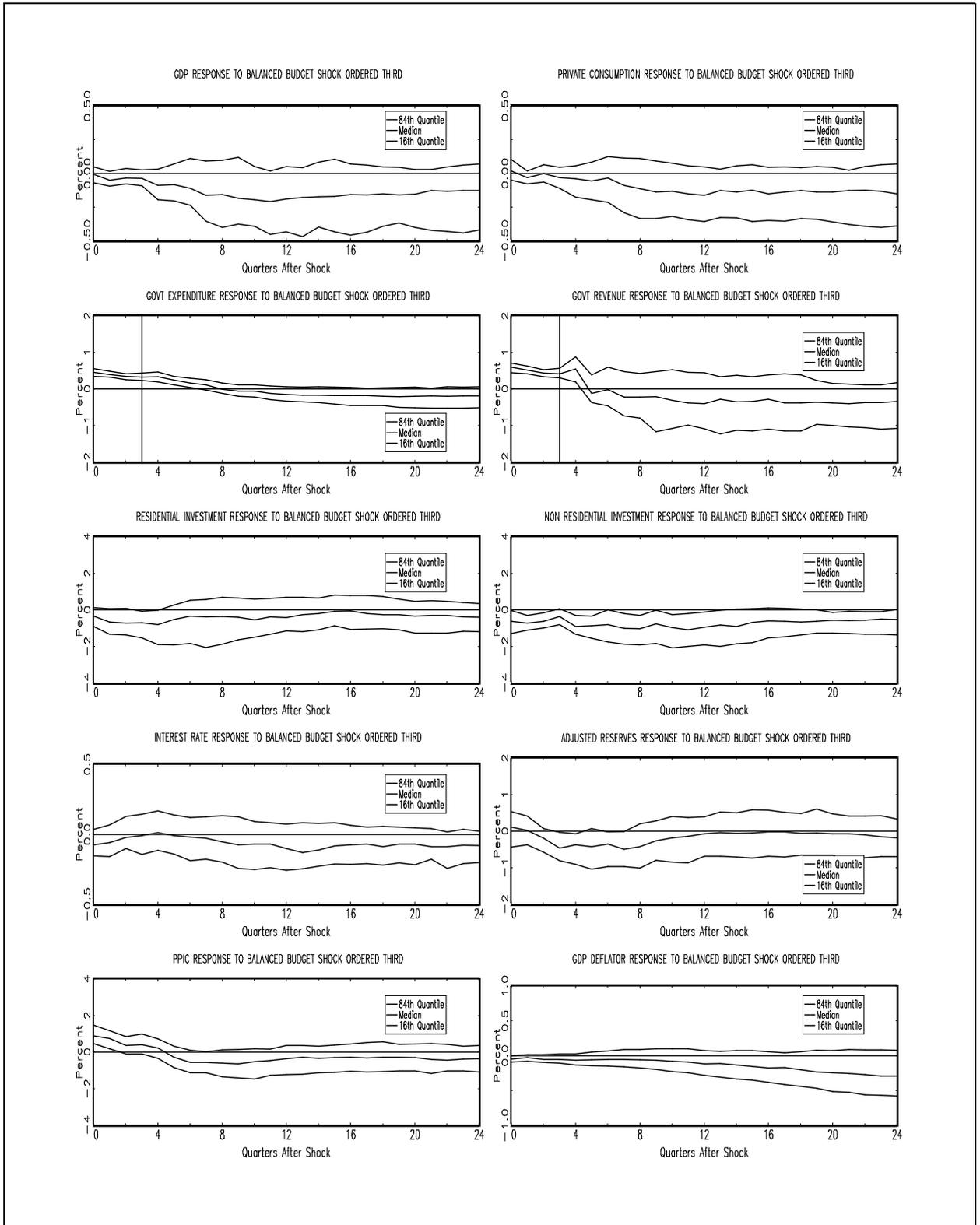Figure 7: **The deficit spending shock ordered 2nd.**

Figure 8: **The deficit spending shock ordered 3rd.**

Figure 9: **The balanced budget shock ordered 2nd.**

Figure 10: **The balanced budget shock ordered 3rd.**