The Effects of Government Spending: A Disaggregated Approach[*]

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Abstract

We disaggregate government spending into five macroeconomic-relevant components: average wage, employment, purchases of intermediate goods and services, investment and transfers. In a simple RBC model with search and matching frictions in the labour market, these components have different qualitative effects on output. Using simulated data, we show that a VAR with aggregate government spending and output suffers from mispecification problems from ignoring the composition of spending. Using the several identification strategies proposed in the literature to show that the estimated multipliers for the United States vary more across types of expenditure, than across identification methods. We then generalise the Blanchard and Perotti (2002) identification strategy in a VAR with all components. We find that employment have the highest multiplier, while purchases of goods and transfers have negative multipliers.

JEL Classification: E62 .

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1   Introduction

During the current economic crisis, one of the most relevant questions posed by policy makers was how much can government spending stimulate output. Economists find it hard to answer

this question. On the one hand, theoretical models often predict different, and sometimes opposite, effects of government spending on several macroeconomic variables such as real wages, private employment or private consumption. On the other hand, the empirical literature has not been able to shed much light on the debate. Most studies disagree on the size of the fiscal multipliers and on the effects of government spending on the key macroeconomic variables (Perotti (2008)).[1]

The source of this disagreement has usually been attributed to the methodology of the identification of fiscal shocks. Blanchard and Perotti (2002) impose a restriction on the timing of the response of government spending to shocks on output. Mountford and Uhlig (2009) impose sign restrictions to identify monetary policy, business cycles, government spending and tax shocks. Ramey and Shapiro (1998) follow a narrative approach, isolating the dates of exogenous events that lead to military buildups in the United States. More recently, following Ramey (2011), the research has focussed on the timing and anticipation of fiscal shocks.

We argue that the identification strategy is not the only explanation for this mixed evidence. Government spending includes several components, such as government investment, transfers or government consumption. Within government consumption, the biggest share is the compensation to government employees but the more volatile component is the purchases of intermediate goods and services. If the components of fiscal policy have different macroeconomic effects, by including all components together, some in particular or using different samples in which the composition of spending has changed, we cannot expect to identify properly any type of fiscal shocks.

Even in the absence of nominal rigidities, there are good theoretical reasons to expect that different types of expenditure have distinct macroeconomic effects. Baxter and King (1993) find that government investment has different quantitative and qualitative effects than government consumption. Because it affects the marginal productivity of factors in the private sector, it can, for instance, crowd in private investment. Finn (1998) finds that, contrary to government purchases of goods and services, an increase in hours raises

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[1]The empirical literature is, in fact, extensive. Rotemberg and Woodford (1992) find that after a military expenditure shock (government military purchases and military employment) real wages go up but Edelberg, Eichenbaum, and Fisher (1999) and Ramey and Shapiro (1998) find that after a government military purchases shock real wages go down. Blanchard and Perotti (2002), Fatás and Mihov (2001) find that private consumption increases after a government consumption shock but Mountford and Uhlig (2009), Ramey (2009) and Tenhofen and Wolff (2007) report a negative or zero response. See Caldara and Kamps (2008) for a survey.

real wages and reduces private employment. Pappa (2009) finds similar results in a New Keynesian setting.

There is also empirical evidence supporting our hypothesis. Lane (2003) measures the cyclicality of different spending categories across OECD countries and finds that they are very heterogeneous. In particular, wage consumption is more procyclical than non-wage consumption. Recently, in his handboock chapter, Perotti (2008) in one exercise, distinguishes between government employment and a goods spending shock and find that both GDP and private consumption respond much more to the employment component of government spending. In a series of papers in the 1990s by Alesina and Perotti, they analyse the impacts of fiscal adjustments in OECD countries and find that they depend crucially on the composition.[2] Alesina and Perotti (1995) find that the most successful episodes were based on spending cuts on transfers and on the wage bill. These ones were also more likely to foster growth and private investment. There are also findings that the wage component of government consumption causes much stronger contractions in exports (Lane and Perotti (1998)), as well as in private investment and profits (Alesina, Ardagna, Perotti, and Schiantarelli (2002)).

Our objective is to do a deeper study of the implications of the heterogeneous effects of the different types of spending, on the estimation of spending multipliers. We disaggregate government spending into macroeconomically relevant components: the wage bill (product of government employment and the average wage), purchases of intermediate goods, investment, transfers and interest payments. Using quarterly data for the United States, we examine the properties of each component, such as: the size, volatility, persistence and comovement. In absolute value the correlation among all components is below 0.5. Wages and employment are less volatile, more persistent and more procyclical than the other components. The weight of each component in total spending changes throughout the sample, as well as the volatilities and their correlation with total spending and with real GDP.

In the first part of the paper we show the potential mispecification problems of VAR studies that do not disaggregate spending, in the context of a simple RBC model with search and matching frictions in the labour market in the spirit of Quadrini and Trigari (2007) or Gomes (2010). First, we show that, even in such a basic setting, the components of spending have different quantitative and qualitative effects on output. Second, we simulate data from the model with technology shocks and government spending shocks (wages, employment, consumption and investment). We then estimate a VAR with aggregate government spending

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[2]See Perotti (1996) for a brief summary.

and output. This theoretical exercise offers three important conclusions: i) the estimated effect of government spending on output seems very weak, because it averages the opposite effects of the different components and ii) changing the relative volatility of shocks and their correlations to match different subsamples in the data, can generate different estimated responses.

These last results motivate our empirical study. We use a VAR approach to identify the effects of the different types of expenditure. First we reproduce five different identification strategies proposed in the literature: Blanchard and Perotti (2002), Mountford and Uhlig (2009), Perotti (2008), Ramey (2011) and Ramey and Shapiro (1998). We substitute government spending for its different components. If our hypothesis is not valid, we would expect little differences in the impulse responses or multipliers. In reality, both the impact and the present value multipliers are very heterogenenous, independent of the identification approach. The difference of multipliers across components is, as large as the differences across identification methods.

Finally, to have more robust estimates of multipliers, we generalize the identification approach by Blanchard and Perotti (2002), to include all the different types of spending, to capture possible complementarities and substitutability between them. We find that wage and employment are the component with the largest long-run present value multiplier. Purchases of intermediate goods and specially transfers have negative multipliers.

The paper continues as follows. In section 2 we describe the data and show some basic facts about the components of spending. Section 3 studies the effects of the components of spending in an RBC model with search and matching frictions and then carries a VAR estimation with simulated data to highlight the potential problems. In Section 4 we reproduce the main studies in the empirical literature, substituting total spending by each of its components. In section 5 we estimate a VAR including all the different components. Section 6 concludes the paper.

2   The composition of government spending

The purpose of this section is to provide a detailed descriptive analysis of what we call macroeconomically relevant components of government spending. We shall start with a discussion of the national accounts of the data and then study compositional changes in government expenditures across time, as well as changes in stability, volatility, persistence and co-movement with other variables.

2.1 Preliminary concepts

The US national accounts provide mainly two measures of government spending. The first measure is the contribution of the government sector to GDP, referred as "Government consumption expenditures and gross investment". Government consumption expenditures include intermediate goods and services purchased and the value added of the sector which is measured at the costs of production: *compensation paid to general government employees* plus *consumption of government owned fixed capital*, also known as depreciation. From the aggregate, the BEA subtracts a part of production which is sold to the private sector (*sales to other sectors*) and *own-account investment*.[3]

Additionally, there is a broader measure of total expenditures. This includes the government consumption expenditures and gross investment plus transfers and interest payments. It also includes two other categories: *Capital transfer payments* and *Net purchases of non-produced assets* (that sum up to 0.5% of total expenditure) and subtracts the depreciation of fixed capital, included in Government consumption expenditures, but which is not an actual expenditure.

Another fact related to the national accounts is how the BEA estimates these two measures in real terms. While price indexes for most components are standard, the real compensation of general government employees is calculated based on a volume indicator. The BEA creates a government employment index, and adjusts it for changes in experience and education, while all other changes in the costs of labour inputs are included in the deflator, and therefore do not enter any measure of real government spending. This means that increases in government wages, do not enter in the measure of real government consumption as they simply enter the implicit price deflator, nor they enter directly in the measure of real GDP if we use the GDP implicit price deflator.

We have two definitions of total spending, to encompass most of the papers in the literature. One, is the sum of three components: the public sector wage bill which can be decomposed into the product between the wage (ω_t^g) and employment (l_t^g), purchases of intermediate goods and services (c_t^g) and investment (i_t^g). The second definition, also includes transfers (t_t^g) and interest payments (r_t^g).

$$Gov_t^1 = \omega_t^g l_t^g + c_t^g + i_t^g. \tag{1}$$

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[3]Own-account investment is investment in structures and in software produced by Federal government employees and are included in general government gross investment. On average, it corresponds to only 5 percent of government gross investment.

$$Gov_t^2 = \omega_t^g l_t^g + c_t^g + i_t^g + tr_t^g + r_t^g. \tag{2}$$

All data are taken from the National Income and Product Accounts of the Bureau of Economic Analysis: Government purchases of intermediate goods and services, Gross Government Investment, Government transfers, Government Interest payments and Compensation of General Government Employees. One possibility to calculate the average wage is to by divide total compensation by *All Employees: Government*. However, all changes in the quality of employment would contaminate the wage measure. We therefore prefer to use the price index of Compensation of General Government Employees, as a measure of nominal wages.[4] We deflate all government variables using the CPI, with the exception of employment.[5].

Many of the empirical studies of the macroeconomic effects of government spending, focus simply on government consumption. In theoretical papers, government consumption usually refers to goods and services bought from the private sector. However, the official definition of government consumption includes the public sector wage bill, purchases of intermediate goods and services minus goods and services sold to the private sector and the consumption of fixed capital (depreciation). This last category is purely an accounting value, and it is not an actual expenditure. Throughout the paper we are going to refer purchases of intermediate goods and services (c_t^g) as consumption. This component is the one consistent with the theoretical models when referring to government consumption.

Before looking at the data, we should start by making a simple typology of the fundamental properties of the different types of spending. The first distinction we make, it that not all types of expenditure use resources. On the one hand, consumption and investment use final goods and employment uses inputs of the economy. On the other hand, like transfers and interest payments, public sector wages simply reallocate resources from the general taxpayer to a specific group of people, in this case public sector workers. A second important distinction between the components is that while the transmission mechanism of consumption and investment affect the final goods market, wage and employment work mainly through the labour market.

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[4]When we add these categories in nominal terms, the second measure of total government spending is on average 5 percent above the official value from the Bureau of Economic Analysis. This originates from the fact that, on top of the current expenditures and gross government investment, the BEA includes capital transfer payments and deduces the sale of goods and services to the private sector.

[5]Initially, to account for changes in the relative price, we deflated the intermediate goods and services and investment with their own price deflator. However, we now prefer to use CPI across all components for the purpose of consistency between the aggregate measure and the sum of the components. The deflator used, does not affect the properties of the series.

2.2 Size

Figure 1: Evolution of government expenditure and its components
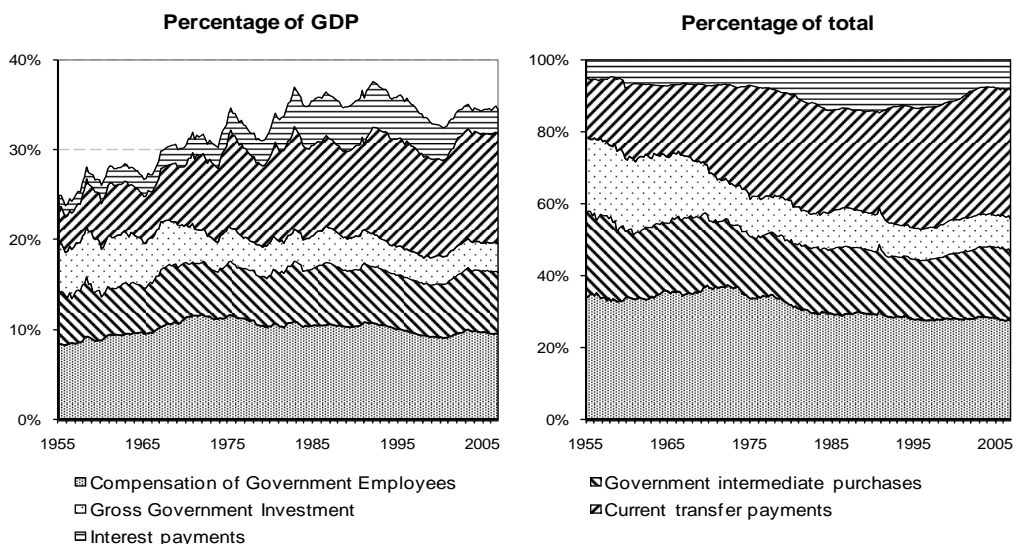

Figure 1 shows the evolution of government spending with its several components. All the five components of government spending are important. On average, the public sector wage bill and transfers correspond to 30 percent of total spending, purchases of intermediate goods and services is 20 percent of spending, investment corresponds to 13 percent while interest payments are close to 10 percent. Total government spending as a share of GDP has increased throughout the sample from 20 to 35 percent of GDP. This was mostly driven by the increase in transfers and in purchases of intermediate goods. The weight of the public sector wage bill and investment on total spending decreased by around 6 and 10 percentage points, while transfers have increased by almost 20 percentage points.[6]

2.3 Volatility, persistence and comovement

To analyse the properties of the different types of spending, we first detrend the data using an HP-filter.[7] Table 1 shows the correlation between each component of spending, as well as with aggregate measures of government spending and economic activity. The last two columns show the standard deviation and the first-order autocorrelation coefficient of the series.

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[6]Figure 6 in Appendix B plots each component of spending, in real terms.

[7]The variables are shown in Figure 7 in Appendix B.

The first relevant fact is that, with the exception of interest payments, all other components are positively correlated with the aggregate measures of government spending. The correlation of total spending with consumption or investment is high but far from perfect. It is between 0.6 and 0.8 depending on the measure of spending. Transfers have a correlation of 0.6 with total expenditure. On the other hand, the correlation it is much lower for employment (0.34 to 0.47) and, particularly for wages (between 0.11 to 0.14). Another striking fact is that the correlation among the different types of expenditures is not very high. All correlations are below 0.5, and particularly wages and interest payments have a negative correlation with all other components.

The volatility of the series is also quite different. Consumption, investment and interests are the most volatile components with standard deviations around 0.04, followed closely by transfers. The wage and employment are less volatile with standard deviations between 0.008 and 0.013. Wages and employment are also more persistent with an autocorrelation coefficients of 0.8 and 0.9, while for investment it is 0.7 and for consumption 0.6.

Table 1: Correlations and standard deviations on the 1955:2006 sample

Correlations	Wage	Employment	Consumption	Investment	Transfers	Interest	Stddev	AR(1)
Wage	1						0.013	0.819
Employment	-0.277	1					0.008	0.893
Consumption	-0.072	0.350	1				0.036	0.588
Investment	-0.212	0.495	0.357	1			0.041	0.673
Transfers	0.094	-0.013	0.152	0.069	1		0.032	0.633
Interest	-0.134	-0.100	-0.322	-0.063	-0.297	1	0.042	0.730
Gov 1	0.140	0.468	0.820	0.702	0.172	-0.276	0.018	0.791
Gov 2	0.113	0.341	0.703	0.594	0.600	-0.177	0.015	0.793
Unemp.Rate	-0.051	-0.226	0.048	-0.112	0.575	-0.375	0.116	0.885
GDP	0.316	0.149	-0.052	0.126	-0.403	0.212	0.016	0.848
GDP lead(4)	-0.347	0.525	0.042	0.226	-0.397	0.189		
GDP lead(1)	0.123	0.238	-0.043	0.086	-0.533	0.285		
GDP lag(1)	0.479	0.070	-0.080	0.084	-0.223	0.051		
GDP lag(4)	0.591	-0.224	0.001	-0.072	0.105	-0.217		

Notes: variables in logs were previously detrended using an HP filter with parameter 1600. AR(1) corresponds to the autocorrelation coefficient of order 1. Gov 1 is real government consumption expenditures and gross investment, while Gov 2 also includes transfers and interest payments. GDP is deflated using the GDP deflator, while the government variables are deflated using CPI.

Finally, we can relate each component with two measures of economic activity: unemployment rate and real GDP growth. Wage, employment and investment are procyclical but with low correlation. On the other hand, transfers have a correlation of -0.40 with real GDP growth and of 0.58 with unemployment. Government wage is more correlated with the lags of GDP, while employment has a correlation of 0.53 with the 1 year lead of GDP.

2.4   Stability

These properties, however, change throughout the sample.[8] For instance, the standard deviation of consumption and investment has fallen significantly throughout the sample. During the first years of the sample the two components had a standard deviation as high as 0.05-0.06, but it gradually came down to 0.02. By the end of the sample, these components are not more than twice as volatile as wages or employment. Also, total spending seems driven by different expenditures over different periods. It was uncorrelated with the average wage at the beginning of the sample and since the mid-80s, the correlation is around 0.5. The cyclicality of each component also varies substantially throughout the sample. Transfers is the component that can be labeled as being consistently countercyclical. All other components vary from slightly procyclical at some stages to slightly countercyclical during other periods.

2.5   Specific Episodes in Components

Table 2 shows the periods of abnormal fiscal events, defined as a percentage change higher than three standard deviations. While there is only three dates of large swings in total spending, there has been 16 episodes within the different components. In the second quarter of 1958, total government spending increased by 3.9 percent, mostly because a very large increase in purchases of intermediate good of more than 10 percent. However, in the same period the wage fell by 4 percent. Another episode of a large drop on wages was in the first quarter of 1955, with a fall of 10 percent. The abnormal changes in transfers seem, in general, related to recessions.

Table 2: Large changes in government spending components in the 1955:2006 sample

Wage	Employment	Consumption	Investment	Transfers	Gov 1	Gov 2
sd Δw^g=0.013	sd Δl^g=0.005	sd Δc^g=0.033	sd Δi^g=0.033	sd Δt^g=0.028	sd Δg^1=0.012	sd Δg^1=0.010
55q1 (-0.107)	66q2 (0.017)	56q3 (-0.146)	78q2 (0.123)	59q1 (0.084)	65q3 (0.042)	58q2 (0.039)
58q2 (-0.041)		58q2 (0.101)		70q2 (0.132)	67q1 (0.046)	65q3 (0.038)
		58q3 (-0.101)		75q2 (0.087)		67q1 (0.046)
		59q1 (-0.125)		80q3 (0.095)		
		60q1 (-0.120)		91q1 (-0.108)		
		67q1 (0.106)		91q2 (0.103)		

Notes: Δx^g are quarter-on-quarter changes of the log of real variables (employment not in real terms) normalized by the size of the population. Episodes selected are the ones where the change in absolute levels is bigger than three standard deviations ($\left|\frac{\Delta x^g}{sd}\right| \geq 3$).

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[8]Shown in Figures 8, 9, 10 and 11 in Appendix B.

The literature has focus on specific cases of military buildups. Figure 1 shows the evolution of the composition of spending in each of the periods: the Vietnam war (1965:1) and the Carter-Reagan buildup (1980:1) and the September 11 (2001:3). We can see from the three figures that the responses in the three events are very distinct in terms of the composition of spending. For the Vietnam War, most of the increase in spending is driven by the 10 percent increase in transfers that lasted for 4 years. Employment, consumption and investment increase slightly in the first year, but then they fall sharply thereafter. For the Carter-Reagan buildup, we see that, despite generating an increase in military spending, it did not increase total spending. Employment and consumption feel sharply. The buildup to the war on terror also seemed very particular. It consisted of a slight but long lasting increase of government consumption, employment and consumption, accompanied by a big tax cut. All in all, the three episodes are very heterogeneous.

Figure 2: Response to different components to military buildups
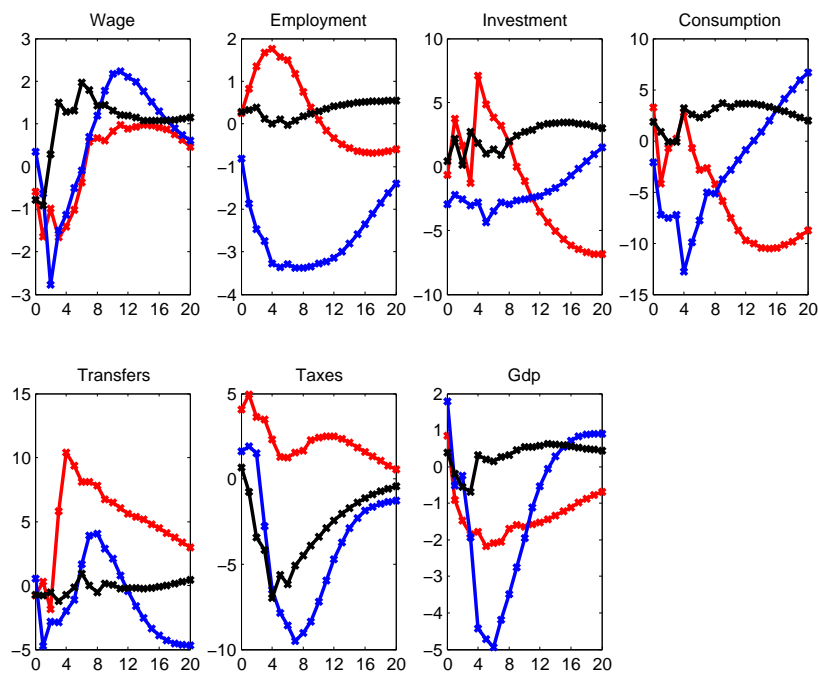
Note: The red line is the Vietnam war, the blue line is the Carter-Reagan buildup and the black line is the September 11. Response of a VAR, with the components, taxes and output and a dummy variable at the onset of each of the episodes.

3   Problems with ignoring composition of spending

To show the potential problems of disregarding the composition of spending, when empirically analysing its effects, we set up a model economy where the government chooses the level of employment, wages, consumption and investment.[9] The only difference between consumption and investment is that the later builds up the public capital stock which raises the private sector productivity. The economy is a simple RBC economy with only search and matching frictions, similar to Quadrini and Trigari (2007) or Gomes (2010). The details of the model and calibration can be found in Appendix C. The search and matching frictions allows us to have a more realistic description of the labour market, which is important when looking at the effects of public sector employment and wages. For instance, if the labour market is frictionless, public and private wages have to be equal, so an increase in public wages would increase the private wage one-to-one. The search and matching friction, does not change the direction of the effects, but only introduces some inertia in the adjustments.

Figure 3 shows the impulse responses of output to a shock to each of the components of spending, normalized such that the increase in total spending is equivalent to 1 percent of GDP and that the autocorrelation coefficient is 0.9. The effects on output are very different across shocks. The effect of a government consumption and investment shocks is positive, but very small in magnitude. This result was already highlighted by Monacelli, Perotti, and Trigari (2010). Employment, on the other hand, has a very high impact multiplier. Employment has a very strong effect in reducing unemployment, particularly at the time of hiring, but the effect on output dies out quickly [Cite paper by LSE guy].. Contrary to these shocks, a wage shock lowers real GDP because it raises private sector wages, crowds out private employment and raises unemployment rate.

Using this model, we simulate data, including a technology shock and the four government spending shocks: wage, employment, consumption and investment. We calibrate the volatility and autocorrelation of the shocks in order to match the properties of the different components and output shown in Table 1. We then estimate a two-variable VAR with total government spending and output. We run 10000 VAR's with 4 lags, with a sample of 350 observations each. To get the impulse responses of other variables (private wages, employment and consumption and the unemployment rate), we run alternative VAR substituting in turns, output for the variable of interest. The mean response and the 16th and 84th percentil are shown in the left panel of Figure 4.[10]

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[9]For the model, we are going to abstract from transfers.

[10]We also estimate a 5 variable VAR with all the different components, where we impose that the off-

Figure 3: Theoretical effect of fiscal shocks in key variables
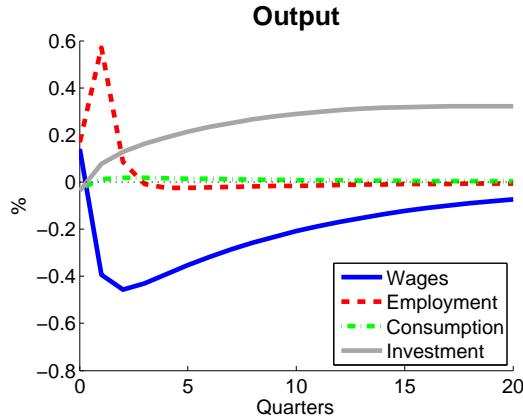
Notes: the theoretical response to a 1 percent of GDP fiscal shocks: wages (solid line), employment (dash line), consumption (dotted line) and investment(dash-dotted line).

We can conclude that aggregating spending can lead to a small aggregate effect. As each component has opposite effects on output the aggregate response seems to average them out with wide error bands. While it is valid to interpret the response and the average government spending shock, it is wrong to conclude that all the different shocks would have similar multipliers, as some might stimulate output whilst other contract it.

Another potential identification problem arises when we estimate the VAR with different samples in which the structure of the fiscal shocks is different. This could lead to different responses and interpretations. To illustrate this, we perform the above described simulation exercise based on different assumptions on the relative importance of the various spending shocks. We simulate three sets of data, from the same economy, but vary the covariance structure of shocks. We use numbers to match the US economy for the periods 1955-1972, 1972-1989 and 1989-2006. The numbers are reported in Table 3. As we have illustrated in section 2, we can observe a strong decline in the volatility of all components across the sample 1955-2006, particularly for consumption and investment. There has also been slight changes in the covariance structure of the variables. The right panel of Figure 4 displays average estimated responses of Output to total spending for the three different periods.

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diagonal elements of the covariance matrix of the components is zero. The graphs are in Appendix E. In general, the average VAR response would capture well the theoretical impulse responses of each component, with the exceptions of employment and investment shocks. In the model agents anticipate the increase in employment in the previous quarter when vacancies are posted. This leads to a small distortion in the response of some variable. Regarding investment, the VAR with 4 lags does not do a good job capturing its long run effects, particulary between the 10th and 20th quarter. The error bands are large because we only include 350 observations in the VAR, which can generate different responses. If we increase the sample size of each VAR, all the VAR's converge to the average.

Table 3: Calibration of shock processes

	Unconditional variance				Correlations		
	Sub 1	Sub 2	Sub 3		Sub 1	Sub 2	Sub 3
Wage	0.0107^2	0.0189^2	0.0078^2	**Wage-Employment**	-0.34	-0.27	-0.23
Employment	0.0095^2	0.0087^2	0.0055^2	**Wage-Consumption**	-0.28	0.13	0.00
Consumption	0.0564^2	0.0242^2	0.0116^2	**Wage-Investment**	-0.33	-0.16	-0.22
Investment	0.0487^2	0.0461^2	0.0206^2	**Employment-Consumption**	0.50	0.11	0.29
Output	0.0152^2	0.0199^2	0.0097^2	**Employment-Investment**	0.59	0.44	0.34
				Consumption-Investment	0.43	0.26	0.18

Although the economy is the same, as are the intrinsic responses to the different components, changing the structure of the shock (either the variances or the covariances between the spending shocks), can have a big impact on the average VAR response. Both quantitatively and qualitative, the estimated response is different for output.

The theoretical exercise in this section offers two important conclusions. First, the estimated effect of government spending on output might seem weak, because it averages the opposite effects of the different components. Second, changing the relative volatility of shocks and their correlations, can generate different estimated responses.

Figure 4: Estimated impulse responses to a total government spending shock (different periods)
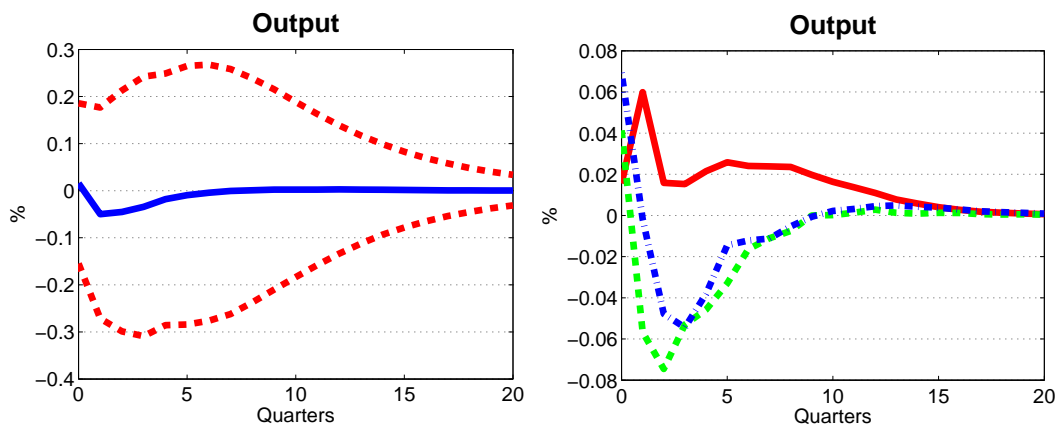
Notes: On left right panel is the VAR response (solid line), confidence bands at 16% and 84% (dashed line) to a 1 percent of GDP government spending shock. Data simulated from the model described in Appendix C. Impulse response functions estimated in a two-variable VAR with total spending and Output on a sample of 350 observations. 10,000 replications. In the right panel has the response for the shocks calibrated for the different subperiods. Response to a 1 percent of GDP government spending shock: period 1 (solid line), period 2 (dash line) and period 3 (dash-dotted line).

4 Disaggregation in existing identification settings

The discussion of the effects of government spending has centered around the identification method. To have a sense of the importance of disaggregation relative to identification, we explore it in the context of the existing methods in the literature: Blanchard and Perotti (2002) and Perotti (2008) structural VAR approach, the dummy variable approach first used by Ramey and Shapiro (1998) and Ramey (2011) which accounts the problem with the anticipation of shocks.

We are going to estimate the impact multiplier and the 5 year present value multiplier when we use an aggregate measure of spending (*gov*1 which includes the wage bill, purchases of intermediate goods and services and investment). We will then use in turns the individual components to compute the multipliers. We then shock each variable such that the increase in government spending is equal to 1 percent of GDP. For instance, government investment corresponds to 4 percent of GDP on average, so a shock of 25 percent to investment is equivalent to 1 per cent of GDP. For the wage bill, it corresponds to 12 percent of GDP on average, so a shock of the size of 1 per cent of GDP is equivalent to a shock of 8.4 percent to either the average wage or employment. Because the literature usually abstracts from transfers, for now, we follow the common procedure of including taxes net of transfers.

The results are shown in Table 4. All the details regarding the specification of the VAR are described the the notes of the table. First, the differences of both the impact and the 5-year present value multiplier across identification strategies is smaller than the differences across components for each identification strategy. While the impact multiplier of total spending varies between 0.67 and 1.75, the the impact multiplier using Blanchard and Perotti varies between 0.4 for consumption to 3 of employment. While the point estimate of the present value multiplier are quite heterogeneous, the error bands are very large.

5 Interaction between components

Our analysis so far is limited, in the sense that it does not allow for interactions between the different types of spending. The components might have different patterns of substitutability or complementarities that we have not captured so far. A shock to one particular type of spending, might be done at the expenses of other types of spending. To address this issue, we generalize the Blanchard and Perotti identification approach to include the five main types

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Table 4: Effects of 1% of GDP fiscal shocks on GDP following different methodologies

Type	Impact multiplier			Present Value Multiplier (20 qt)			
	B&P	P	R	B&P	P	R	R&S
Total Spending	1.08	0.67	1.75	1.84	1.75	1.18	0.53
	[0.80;1.38]	[0.43;0.96]	[1.07;2.57]	[1.23;2.43]	[1.00;2.54]	[-1.29;4.02]	[-0.30;1.47]
Wage	0.82	-0.10	-6.59	5.49	4.08	1.12	4.97
	[-0.13;1.80]	[-0.81;0.68]	[-15.48;-2.72]	[3.59;5.49]	[2.23;6.35]	[-13.97;15.73]	[-5.10;15.56]
Employment	2.97	3.46	25.05	3.69	1.94	-0.81	4.57
	[0.64;4.98]	[1.33;5.62]	[-10.80;78.35]	[1.49;5.37]	[-1.47;4.34]	[-11.29;5.24]	[-4.31;13.07]
Consumption	0.40	0.38	2.08	2.34	3.40	-0.19	1.10
	[0.02;0.81]	[0.02;0.74]	[1.13;3.30]	[0.21;4.19]	[1.73;5.22]	[-9.09;5.79]	[-2.20;4.48]
Investment	1.77	0.99	3.80	2.09	0.80	3.29	0.87
	[1.09;2.40]	[0.45;1.55]	[2.32;5.79]	[-0.26;4.53]	[-1.87;3.52]	[-4.45;11.40]	[-7.22;10.00]

Notes: For Blanchard and Perotti the VAR is estimated with 4 lags, linear and quadratic time trend. The VAR includes government spending (rotating each component in turns), taxes net of transfers and GDP. We assume that the contemporaneous elasticity of government spending to output is zero, that the elasticity of net taxes to output is 2.08 and that the decision of spending are taken before the decision on taxes. The sample starts in 1955:1 and runs until 2000:4. Standard deviations are bootstrapped based on 1000 repetitions. The sample starts in 1955:1 and runs until 2000:4. Standard deviations are bootstrapped based on 100 repetitions. For Perotti the VAR is estimated with 4 lags, linear and quadratic time trend. The VAR includes government spending (rotating each component in turns), the Barro-Sahasakul average marginal income tax rate, GDP, private consumption on non-durables and services, private gross fixed investment, hours worked in the non-farm business sector and the real product hourly compensation in the non-farm business sector. The sample starts in 1955:1 and runs until 2000:4. As the marginal tax rate is a political variable, it is assume not to respond contemporaneously to other macroeconomic variables. Standard deviations are bootstrapped based on 1000 repetitions. For the Ramey, we use the same VAR as Perotti, add the news shock based on the survey of professional forecasters and compute the impulse responses of spending and output to a shock in this variable,. The sample is restricted to 1969:1 to 2006:4. Standard deviations are bootstrapped based on 1000 repetitions. For the dummy approach we extend the sample from 1950:1 to 2006:4 to include the four dates. Standard deviations are bootstrapped based on 1000 repetitions. In all cases the error bands are at 16% and 84%. For Ramey and Shapiro, we estimate a VAR with 6 lags, linear and quadratic time trend. The sample starts in 1950:1 and runs until 2010:3 We include a dummy that assumes value 1 at the following four dates: Korean war (1950:3), Vietnam war (1965:1), the Carter-Reagan buildup (1980:1) and the September 11 (2001:3) To compute the response to an episode, we exclude the estimated dummy from the output equation.

of expenditures and propose a new way to interpret structural innovations that distinguishes between idiosyncratic and global shock components.

We estimate a VAR with seven variables: employment, wages, consumption, investment, transfers, taxes and output. We maintain Blanchard and Perotti's identification assumptions, assuming that the innovations in output do not affect general government expenditure contemporaneously at a quarterly frequency. The only exception is transfers and taxes. With respect to the effect of output on transfers, B&P estimate it to be -0.2. We then back out the effect of output on total taxes which is around 1.8.

The main difficulty of looking at the effects of the different components is how to identify the shocks to each particular component. This question was also present in Blanchard and Perotti, between government spending or taxes. They disregard this problem and argue that whether taxes respond to spending or spending responds to taxes does not affect their results. When we include six government variables, the problem becomes more complicated. First, there is no theoretical suggestion on how to order these components. Also, given that we have 6 variables, trying different orderings is as cumbersome as unsatisfying.

We propose a different approach. The budget policy is decided simultaneously, so any

attempt to order the variables is artificial. We argue that the residuals are either idiosyncratic shocks to each component, or the result of global fiscal shocks. We retrieve these "global" shocks, by the principal components method. The principal components analysis seeks a linear combination of variables such that the maximum variance is extracted from the variables. It then removes this variance and seeks a second linear combination which explains the maximum proportion of the remaining variance, and so on. Our modeling of the error terms is as follows:

$$
\begin{aligned}
\mu_t^w &= \gamma^w f_t + \epsilon_t^w \\
\mu_t^l &= \gamma^l f_t + \epsilon_t^l \\
\mu_t^c &= \gamma^c f_t + \epsilon_t^c \\
\mu_t^i &= \gamma^i f_t + \epsilon_t^i \\
\mu_t^{tr} &= \gamma^{tr} f_t - 0.2\mu_t^x + \epsilon_t^i \\
\mu_t^t &= \gamma^t f_t + 1.8\mu_t^x + \epsilon_t^t \\
\mu_t^x &= \beta_1 \mu_t^w + \beta_2 \mu_t^l + \beta_3 \mu_t^c + \beta_4 \mu_t^i + \beta_5 \mu_t^t + \epsilon_t^x
\end{aligned}
$$

Where f_t is a vector of factors and γ^i are the vectors of the factor loadings. Notice that to estimate the coefficients β, we only need the residuals so the distinction between factors and specific shocks is not relevant. They are only relevant for the interpretation of the joint policies. For the four first policy variables, that do not respond to output, the structural innovations are the residuals from the VAR even if their are correlated. To estimate the factors, the Kaiser criterion suggests that we retain three factors. Table 5 shows the factor loadings and the percentage of the variance that remains unexplained by the three factors. Jointly, these three factors explain close to 60 percent of the variance of the innovations in the six components.

We interpret the factors not from the factor loadings, but the cumulative spending that it generates on each category. The present discounted value of each component as a fraction of GDP is shown in the last three columns. The first and third factor generate a fall of total spending. The first factor is composed by an increase in taxes, and reduction of transfers and employment compensated by an increase in consumption. The second factor is composed of wage increase and a tax cut. The last factor is composed by an fall of wages and transfers.

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Table 5: Idiosyncratic components and factors

| Variable | PVM | Factor loadings of structural innovations | | | | Long-run spending | | |
	Long-run	Factor 1	Factor 2	Factor 3	% σ^2 unexplained	Factor 1	Factor 2	Factor 3
Wage	1.97	-0.564	-0.013	-0.238	0.504	-0.881	1.252	-0.886
Employment	2.93	-0.294	-0.575	0.452	0.283	-1.111	-0.250	0.238
Consumption	-0.12	0.390	-0.411	0.487	0.332	2.021	0.292	0.064
Investment	0.20	-0.385	0.226	0.435	0.474	0.057	0.350	0.031
Transfers	-1.66	-0.109	-0.669	-0.535	0.348	-2.203	0.107	-0.442
Taxes	-0.25	0.531	-0.004	-0.155	0.517	1.697	-1.262	0.148
Long-run Output						-0.982	0.146	0.081

Notes: The VAR is estimated with 4 lags, linear and quadratic time trend, seasonal dummies and a 4-lag dummy for 1975:2. The sample starts in 1960:1 and runs until 2006:4. The long-run multipliers are computed for 200 quarters. In the last column is the long-run present value multipliers, for each of the components when we do not allow any other variable except output to adjust in the VAR. In the last row, it is the present-value multiplier for a global shock, when all the variables adjust in the VAR

We compute present value multipliers to idiosyncratic and to global shocks.[11] For each individual component we compute the present value multipliers by not allowing any of the respective other components to adjust in the VAR. The resulting multiplier therefore only captures the pure effect of the fiscal variable on output. For the global shocks, we allow all variables to adjust in the VAR. The present value multipliers at different horizons are shown in Figure 5. In the second column of Table 5 there are the long-run present value multipliers of each component.

Figure 5: Present value multipliers

(a) Component specific shocks

(b) Global shocks
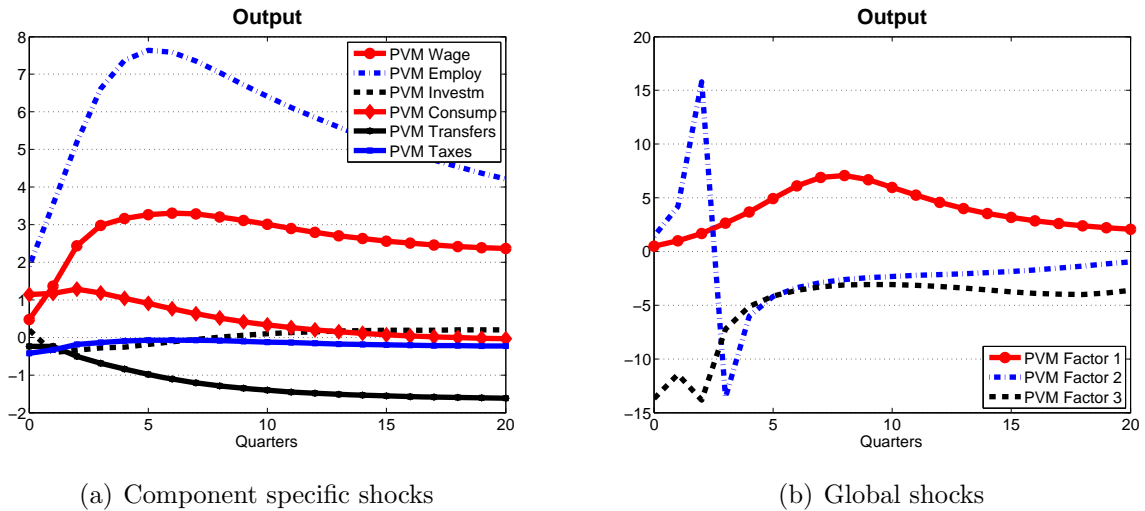
With respect to the individual components, wage and employment have the higher multipliers. Consumption and particularly transfers have negative multipliers. Regarding the factors, the first one has a higher multiplier just bellow 1. The second factor, generates a

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[11]The formulae for the present value multipliers can be found in Appendix.

big multiplier at a very short horizon and then the effect dies out. The long-run present value multiplier is around 0.15. Finally, the last factor has a negative multiplier of -0.22. We interpret this factor as an expansionary fiscal contraction. As has been documented, fiscal consolidations based on reduction of wages and transfers have a good record of stimulating the economy.

In a recent paper, Caldara (2010) derives an analytical relation between the elasticity of spending and taxes with respect to output and the corresponding multipliers. Each of the identification strategies can be interpreted as imposing a different prior on the elasticities with respect to output, which would map directly to different impact fiscal multipliers. In our case, things are more complicated as a different assumption on the elasticity of one component would affect the multiplier of all the others. For that we re-estimate the VAR varying the elasticities of each component from -0.2 to 0.2. We find that, with the exception of transfers, the present value multipliers of the other components are quite robust.

6   Conclusion

The objective of this paper is to highlight a dimension that has been overlooked in this vast literature of the effects of government spending. We disaggregate government spending into five macroeconomic relevant components: average wage, employment, purchases, investment and transfers. Each of these components has very different properties in terms of volatility, comovement with total spending and with output.

We then show, using several identification frameworks, that the fiscal multipliers are very different across types of spending. In order to account for possible substitutability and complementarities between components, we suggest a new identification approach that is based on the distinction between an idiosyncratic shock component and a global one. The applied procedure allows for in interpretation of the policy mixes applied as a response to global shocks. We find that both the average wage and employment have bigger multipliers than purchases of intermediate goods, investment and transfers. While two global factors have positive multipliers, the third factor which is composed of wage and transfer increase, have negative multiplier.,

While this paper does not solve the methodological issues regarding the identification of fiscal shocks, it highlights a dimension that has been overlooked. Our paper has implications for both policy and macroeconomic theory. For policy makers, given the need to start reducing deficits soon, these results suggests that they can reduce government spending

and still have a stimulating effect in the economy if, for instance, they reduce government purchases or transfers and then partially offset with increasing hiring. For macroeconomic theory, we should look more attentively at the effects of different components of spending, namely of government employment and wages.

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Appendix

A Data - Definition and Description

The data on government expenditures comes from the National Income and Product Account tables of the Bureau of Economic Analysis, while the data on government employment comes from the Bureau of Labor Statistics.

1- **Compensation of General Government Employees** is a sub-element of Government Consumption expenditures (Table 3.10.5. Government Consumption Expenditures and General Government Gross Output, Quarterly, Billions of dollars, Seasonally adjusted at annual rates, Line 4).

2- **All Employees: Government** (USGOVT, U.S. Department of Labor: Bureau of Labor Statistics, Monthly (3 Month average for quarter), Seasonally Adjusted, Millions).

3- **Government Per Employee Wage** (Own calculation: Total Compensation to Employees (billions of dollars) divided by number of Employees (Millions).

4- **Government purchases of intermediate goods and services** is a sub-element of Government Consumption expenditures (Table 3.10.5. Government Consumption Expenditures and General Government Gross Output, Quarterly, Billions of dollars, Seasonally adjusted at annual rates, Line 6).

5- **Gross Government Investment** (Table 3.1, Gross government investment, line 35, Billions of dollars, Seasonally adjusted at annual rates)

6- **Government transfers** (Table 3.1, Current transfer payments, line 17, Billions of dollars, Seasonally adjusted at annual rates)

7- **Government Interest payments** (Table 3.1, Interest payments, line 22, Billions of dollars, Seasonally adjusted at annual rates)

8- **Total Government Expenditure (Our)** The measure of government spending used throughout the paper is the sum of the expenditures (1, 5, 6 and 7).

9- **Total Government Expenditure (BEA)** (Table 3.1, Total expenditures, line 33, Billions of dollars, Seasonally adjusted at annual rates). It is composed by: Current expenditures, Gross government investment, Capital transfer payments, Net purchases of nonproduced assets minus Consumption of fixed capital. For the years before 1960, there is no data on Net purchases of non produced assets (corresponds to less than 0.2% of total government expenditures). It does not add to the sum of government consumption, gross investment, transfers and interest payments because they deduce the consumption of fixed capital.

10- **Government Consumption Expenditures** (Table 3.10.5. Government Consumption Expenditures and General Government Gross Output, Quarterly, Billions of dollars, Seasonally adjusted at annual rates, Line 1). Definition: Government consumption expenditures are services (such as education and national defense) produced by government that are valued at their cost of production. It includes *Compensation of General Government Employees*, *Consumption of General Government Fixed Capital* (or depreciation, is included in government gross output as a partial measure of the services of general government fixed assets), *Intermediate Goods and Services Purchased* minus *Own-account investment* and *Sales to other sectors.*

11- **Total Government Receipts** (Table 3.1, Total Receipts, line 30, Billions of dollars, Seasonally adjusted at annual rates).

12- **Government Net Savings**(Table 3.1, Net lending or net borrowing (-), line 39, Billions of dollars, Seasonally adjusted at annual rates).

13:21- **National Accounts** (Table 1.1.5., Billions of dollars, Seasonally adjusted at annual rates)

22:29- **National Accounts Price Deflators** (Table 1.1.9., Index numbers, 2005=100, Seasonally adjusted)

30- **Labour Force** (CLF16OV, Civilian Labor Force, Bureau of Labor Statistics, Seasonally Adjusted, Monthly (3 month average for quarter), Millions, Persons 16 years of age and older.)

31- **CPI** (CPIAUCSL, Consumer Price Index For All Urban Consumers: All Items, Bureau of Labor Statistics, Seasonally Adjusted Monthly (3 month average for quarter), Index 1982-84=100)

32- **FED** (FEDFUNDS, Effective Federal Funds Rate, Board of Governors of the Federal Reserve System, Monthly(3 month average for quarter), Percent)

33- **Nominal Private Wage** (HCOMPBS, Business Sector: Compensation Per Hour,Bureau of Labor Statistics, Seasonally Adjusted, Quarterly, Index 1992=100)

34- **Private total hours** (HOABS, Business Sector: Hours of All Persons, Bureau of Labor Statistics, Seasonally Adjusted, Quarterly, Index 1992=100)

35- **Real private wage** (RCPHBS, Business Sector: Real Compensation Per Hour,Bureau of Labor Statistics, Seasonally Adjusted, Quarterly, Index 1992=100)

36- **Private productivity** (OPHPBS, Business Sector: Output Per Hour of All Persons, Bureau of Labor Statistics, Seasonally Adjusted, Quarterly, Index 1992=100)

37- **Unemployed** (UNEMPLOY, Unemployed, Bureau of Labor Statistics, Seasonally Adjusted, Monthly (3 month average for the quarter), Millions)

38- **Private sector employment** (USPRIV, All Employees: Total Private Industries, Bureau of Labor Statistics, Seasonally Adjusted, Monthly (3 month average for the quarter), Millions)

B   Looking at the data

Figure 6: Components of government expenditure
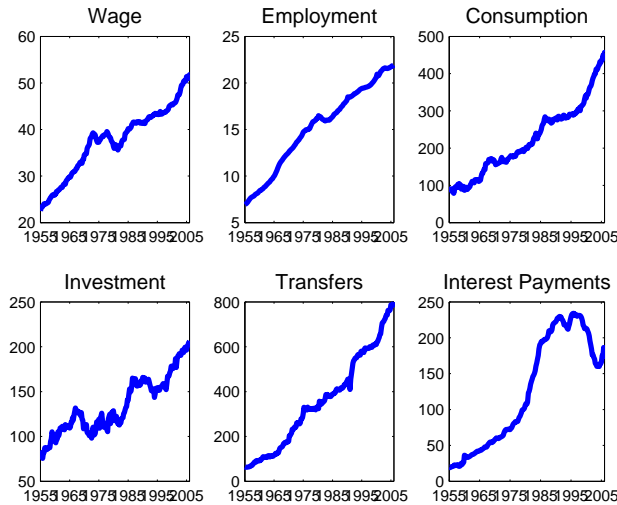
Note: All variables except employment are real. Employment is in millions of employees. Wages is the "Price Index: Compensation of general government employees" deflated with the "Consumer Price Index for All Urban Consumers: All Items". Consumption and investment are "Intermediate goods and services purchased" and "Gross government investment" deflated by their corresponding price indices. Transfers and interest payments are "Current transfer payments" and "Interest payments" deflated by the CPI. CPI and employment are taken from the BLS. All other variables are from the BEA's National Income and Product Accounts.

Figure 7: Deviations from an HP-filtered trend of components of government expenditure

Figure 8: Standard deviations of components of government expenditure on a rolling window of 10 years
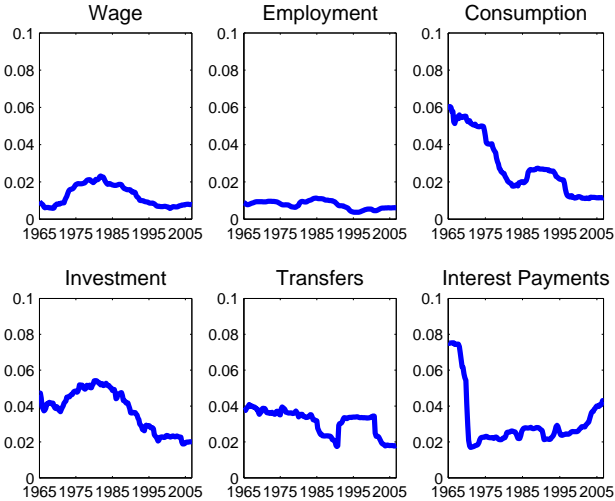
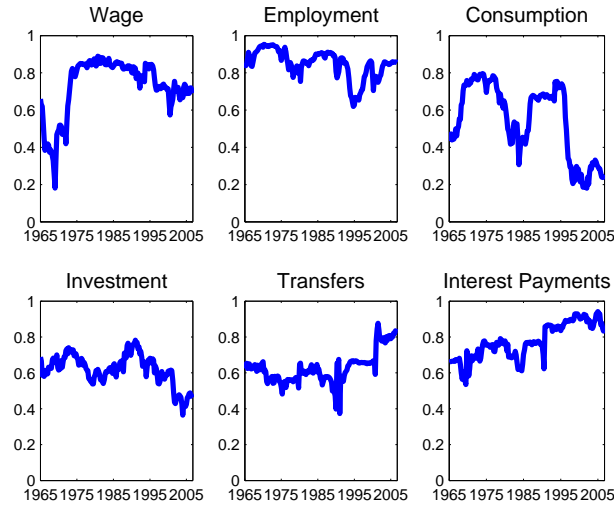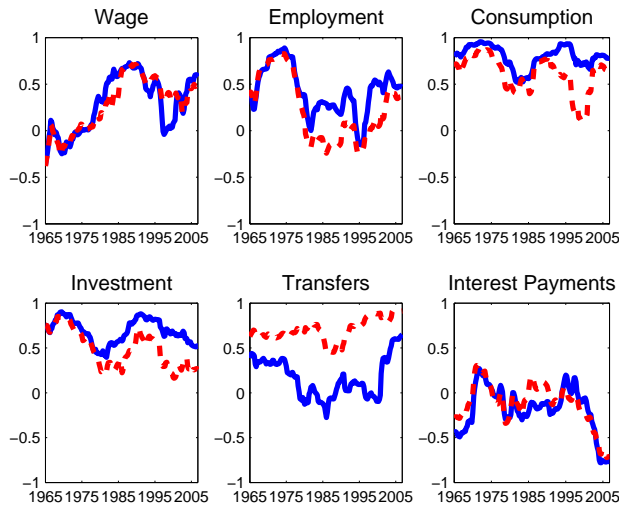Figure 9: Autocorrelation of order 1 on a rolling window of 10 years

Figure 10: Correlation of Government spending with ... (rolling window of 10 years)


Note: Blue solid line is the correlation with Gov 1, which includes the wage bill, purchases of intermediate goods and investment. The red dashed line is the correlation with Gov 2, which further includes transfers and interest payments.

C Model

The theoretical section aims to show the problems of disregarding the composition of spending when analysing its effects. We are going to set up a model economy where the government chooses the level of employment, wages, consumption and investment.[12] The economy is a simple RBC economy with only search and matching frictions. We will first look at the

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[12]For the model, we are going to abstract from transfers.

Figure 11: Correlation of Real GDP with ... (rolling window of 10 years)
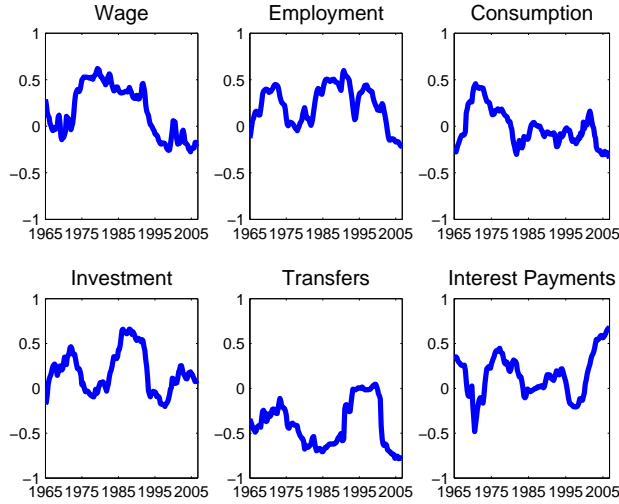
impulse responses to each individual component on several key variables such as output, private wages and employment, private consumption and the unemployment rate. We then simulate the model and estimate a two variable VAR, with total government spending. We will then do a series of exercises, to show the problems with ignoring this heterogeneity.

C.1 General setting

The model is a dynamic stochastic general equilibrium model with public and private sectors. The only rigidities present are due to search and matching frictions. It is an extension of Gomes (2010) to include not only government employment and wages, but also government consumption and investment. Public sector variables are denoted by the superscript g while private sector variables are denoted by p. Time is denoted by $t = 0, 1, 2, ...$

The labour force consists of many individuals $j \in [0, 1]$. Part of them are unemployed (u_t), while the remaining are working either in the public (l_t^g) or in the private (l_t^p) sector.

$$1 = l_t^p + l_t^g + u_t. \tag{3}$$

Total employment is denoted by l_t. The presence of search and matching frictions in the labour market prevents some unemployed from finding jobs. The evolution of employment in both sectors depends on the number of new matches m_t^p and m_t^g and on the separations. In each period, jobs are destroyed at constant fraction λ^i, potentially different across sectors.

$$l_{t+1}^i = (1 - \lambda^i)l_t^i + m_t^i, \; i = p, g. \tag{4}$$

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The new matches are determined by two Cobb-Douglas matching functions:

$$m_t^i = \mu^i (u_t^i)^{\eta^i} (v_t^i)^{1-\eta^i}, \quad i = p, g. \tag{5}$$

We assume the unemployed choose which sector they want to search in, so u_t^i represents the number of unemployed searching in sector i. The vacancies in each sector are denoted by v_t^i. The parameter η^i is the matching elasticity with respect to unemployment and μ^i the matching efficiency. A fraction $s_t = \frac{u_t^g}{u_t}$ of unemployed search for public sector jobs. From the matching functions we can define the probabilities of vacancies being filled q_t^i, the job-finding rates conditional on searching in a particular sector p_t^i, and the unconditional job-finding rates f_t^i:

$$q_t^i = \frac{m_t^i}{v_t^i}, \quad p_t^i = \frac{m_t^i}{u_t^i}, \quad f_t^i = \frac{m_t^i}{u_t}, \quad i = p, g.$$

C.2 Households

Following Merz (1995), I assume all the income of the members is pooled so the private consumption is equalised across members. The household is infinitely-lived and has preferences over private consumption goods, c_t, and public goods g_t. It also has utility from unemployment $\nu(u_t)$, which captures leisure and home production.

$$E_t \sum_{t=0}^{\infty} \beta^t [u(c_t, g_t) + \nu(u_t)], \tag{6}$$

where $\beta \in (0, 1)$ is the discount factor. The budget constraint in period t is given by:

$$c_t + B_t = (1 + r_{t-1})B_{t-1} + w_t^p l_t^p + w_t^p l_t^g + \Pi_t, \tag{7}$$

where r_{t-1} is the real interest rate from period $t-1$ to t and B_{t-1} are the holdings of one period bonds. $w_t^i l_t^i$ is the total wage income from the members working in sector i. Finally, Π_t encompasses the lump sum taxes that finance the government's wage bill and possible transfers from the private sector firms. We assume there are no unemployment benefits.

The household chooses c_t to maximize the expected utility subject to the sequence of budget constraints, taking the public goods as given. The solution is the Euler equation:

$$u_c(c_t, g_t) = \beta(1 + r_t)E_t[u_c(c_{t+1}, g_{t+1})]. \tag{8}$$

C.3 Workers

The value of each member to the household depends on their current state. The value of being employed in sector i is given by:

$$W_t^i = w_t^i + E_t \beta_{t,t+1}[(1 - \lambda^i)W_{t+1}^i + \lambda^i U_{t+1}], \ i = p, g, \tag{9}$$

where $\beta_{t,t+k} = \beta^k \frac{u_c(c_{t+k}, g_{t+k})}{u_c(c_t, g_t)}$ is the stochastic discount factor. The value of being employed in a sector depends on the current wage, as well as, the continuation value of the job that depends on the separation probability. Under the assumption of directed search, the unemployed are searching for a job either in the private or in the public sector, with value functions given by:

$$U_t^i = \frac{\nu_u(u_t)}{u_c(c_t, g_t)} + E_t \beta_{t,t+1}[p_t^i W_{t+1}^i + (1 - p_t^i)U_{t+1}], \ i = p, g. \tag{10}$$

Beside the marginal utility from unemployment, the value of being unemployed and searching in a particular sector, depends on the probabilities of finding a job and the value of working in that sector. Optimality implies that there are movements between the two segments that guarantee that there is no additional gain of searching in one sector *vis-à-vis* the other:

$$U_t^p = U_t^g = U_t. \tag{11}$$

This equality determines the optimal share of unemployed searching in each sector. We can re-write it as:

$$\frac{m_t^p E_t \beta_{t,t+1}[W_{t+1}^p - U_{t+1}]}{(1 - s_t)} = \frac{m_t^g E_t \beta_{t,t+1}[W_{t+1}^g - U_{t+1}]}{s_t}, \tag{12}$$

which implicitly defines s_t. An increase in the value of being employed in the public sector, driven either by an increase in the wage or by a decrease in the separation rate, raises s_t, until there is no extra gain from searching in that sector.

C.4 Private sector firms

The representative firm hires labour to produce the private consumption goods. The production function is linear in labour, but part of the resources produced have to be used to pay the cost of posting vacancies $\varsigma^p v_t^p$.

$$y_t = a_t^p l_t^p - \varsigma^p v_t^p, \tag{13}$$

where a_t^p is the productivity of the private sector which is taken as given for the firms. We assume it depends on the amount of public capital with an elasticity of θ and a productivity shock ϵ_t^a .

$$\ln(a_t^p) = \ln(\epsilon_t^a) + \theta \ln(k_t^g), \tag{14}$$

At time t, the level of employment is predetermined and the firm can only control the number of vacancies it posts. The value of opening a vacancy is given by:

$$V_t = E_t \beta_{t,t+1} [q_t^p J_{t+1} + (1 - q_t^p) V_{t+1}] - \varsigma^p, \tag{15}$$

where J_t is the value of a job for the firm, given by:

$$J_t = a_t^p - w_t^p + E_t \beta_{t,t+1} [(1 - \lambda^p) J_{t+1}]. \tag{16}$$

Free entry guarantees that the value of posting a vacancy is zero $(V_t = 0)$, so we can combine the two equations into:

$$\frac{\varsigma^p}{q_t^p} = E_t \beta_{t,t+1} [a_{t+1}^p - w_{t+1}^p + (1 - \lambda^p) \frac{\varsigma^p}{q_{t+1}^p}]. \tag{17}$$

The condition states that the expected cost of hiring a worker must equal its expected return. The benefit of hiring an extra worker is the discounted value of the expected difference between its marginal productivity and its wage, plus the continuation value, knowing that with a probability λ^p the match is destroyed.

Finally, we consider the private sector wage is the outcome of a Nash bargaining between workers and firms. The sharing rule is given by:

$$(1 - b)(W_t^p - U_t) = b J_t. \tag{18}$$

C.5   Government

The government produces its good using workers and a consumption good purchased from the private sector (c_t^g). The costs of posting vacancies are deducted from production. Unless there is a particular interdependence in the utility function between public and private goods, the production function turns out to be irrelevant.

$$g_t = g(l_t^g, c_t^g) - \varsigma^g v_t^g. \tag{19}$$

Additionally the government also buys from the private sector investment goods (i_t^g), which are used to build up the level of public capital.

$$k_{t+1}^g = (1 - \delta)k_t^g + i_t^g. \tag{20}$$

The government collects lump sum taxes to finance the wage bill, consumption and investment:

$$\tau_t = w_t^g l_t^g + c_t^g + i_t^g. \tag{21}$$

The numeraire of this economy is the private consumption good. As in reality, as the public good is not sold, it has no actual price. The value added of the public sector is going to be measured using the production cost $(w_t^g l_t^g + c_t^g + i_t^g)$.

Finally, the government sets a policy for the sequence of vacancies and wage $\{v_t^g, w_t^g\}_{t=o}^\infty$, consumption $\{c_t^g\}_{t=o}^\infty$ and investment $\{i_t^g\}_{t=o}^\infty$. We are going to focus on exogenous policies to help us understand the functioning of the model and the transmission mechanisms of fiscal policy:

$$w_t^g = \bar{w}^g + \epsilon_t^w, \tag{22}$$
$$l_{t+1}^g = \bar{l}^g + \epsilon_{t+1}^l, \tag{23}$$
$$c_t^g = \bar{c}^g + \epsilon_t^c, \tag{24}$$
$$i_t^g = \bar{i}^g + \epsilon_t^i. \tag{25}$$

Where the steady-state variables are represented with a bar, and ϵ^i are the shocks to each component. In the baseline setting, we consider that an employment shock is achieved through hirings but can only be put in place in period $t + 1$. An alternative would be to consider a shock to vacancies. As there is a one-to-one mapping between a sequence of vacancies and a sequence of employment, the distinction is not relevant.

C.6 Market clearing

To close the model, we need the market clearing condition for the private goods market:

$$y_t = c_t + c_t^g + i_t^g, \tag{26}$$

Notice however that to have a comparable measure to GDP, we need to add the government wage bill:

$$Output_t = c_t + c_t^g + i_t^g + w_t^g l_t^g, \tag{27}$$

This equation measures the nominal GDP in the economy. To avoid the problem that a public sector wage increase translates into a one-to-one increase in GDP, the statistical offices, when presenting the estimates of real GDP, consider the average public sector wage fixed at a base year ($\bar{w}^g$).

C.7   Calibration

To solve the model, we assume a that the utility function is separable in the private and public good and that the utility of unemployment is linear.

$$u(c_t, g_t) = \frac{c_t^{(1-\gamma)} - 1}{(1 - \gamma)} + \zeta \ln(g_t), \ \nu(u_t) = \chi u_t.$$

The model is calibrated to match the US economy at a quarterly frequency. The steady-state vacancies in the public sector are such that public sector employment corresponds to 13.6 percent of the labour force (average from 1955 to 2006). The steady-state levels of government consumption and investment are set to 7 and 4 percent of output. We choose a steady-state public sector wage gap of 2 percent ($\pi = \frac{\bar{w}^g}{w^p}$) which implies a total government wage bill of 14 percent of output.

Most of the labour market parameters follow Gomes (2010). We fix the separation rate in the private and public sectors at 0.06 and 0.03. We set the public sector matching elasticity with respect to unemployment, η^g, at 0.2 and η^p at 0.5. We calibrate the matching efficiency μ^i to such that the duration of a vacancy is 50 days for the government and 20 days for the private sector ($\bar{q}^p = 4.7$ and $\bar{q}^g = 1.8$). We consider the cost of posting a vacancy ς^i to be 2 in the private sector and 1.1 in the public sector. Under this calibration, the sum of recruitment costs is close to 2.5 percent of the total labour costs. For the model to satisfy the Hosios condition in the private sector, the worker's share in the Nash bargaining is set at 0.5. The value of leisure in the utility function is calibrated, such that the unemployment rate in steady state is 0.063 and implies an outside option equivalent to 63 percent of the average wage. Technology in the private sector is normalised to 1 and the discount factor is set at 0.99.

We have three additional variables to calibrate. The productivity of public capital, θ is set at 0.05, following Baxter and King (1993) and the depreciation of public capital is set to 0.02. This implies that the steady-state level of public capital is around 50 percent of annual output. We consider a log utility of private consumption ($\gamma = 1$). Table 6 summarises the baseline calibration and the implied steady-state values for some of the variables.

Table 6: Baseline calibration

Parameters													
γ	1	η^p	0.5	ς^p	2.0	μ^p	1.71	λ^p	0.06	χ	0.46	δ	0.02
β	0.99	η^g	0.2	ς^g	1.1	μ^g	1.97	λ^g	0.03	b	0.5	θ	0.99
π	0.98	$\bar{i}^g$	0.037	$\bar{l}^g$	0.136	$\bar{c}^g$	0.065						
Steady-state variables													
$\bar{u}$	0.062	$\bar{q}^g$	1.8	$\bar{f}^g$	0.065	$\bar{p}^g$	1.45	$\bar{s}$	0.05	$\frac{\varsigma^p \bar{v}^p + \varsigma^g \bar{v}^g}{\sum \bar{w}^i \bar{l}^i}$	0.025	$\frac{\bar{c}^g}{\bar{y}}$	0.07
$\bar{l}^p$	0.80	$\bar{q}^p$	4.7	$\bar{f}^p$	0.77	$\bar{p}^p$	0.80	$\frac{\nu_l}{u_c \bar{w}^g}$	0.63	$\frac{\bar{w}^g \bar{l}^g}{\bar{y}}$	0.14	$\frac{\bar{i}^g}{\bar{y}}$	0.04

D   Present value multipliers

- PVM to component specific shocks:

$$PVM_k^x = \frac{\sum_{j=0}^k \beta^j \hat{y}_j}{\sum_{j=0}^k \beta^j \hat{x}_j} \frac{1}{x/y}$$

with $\hat{y}_j$ ($\hat{x}_j$) the response of GDP (the fiscal variable) at period j, β is the discount factor, x/y is the average share of the fiscal variable in GDP over the sample.
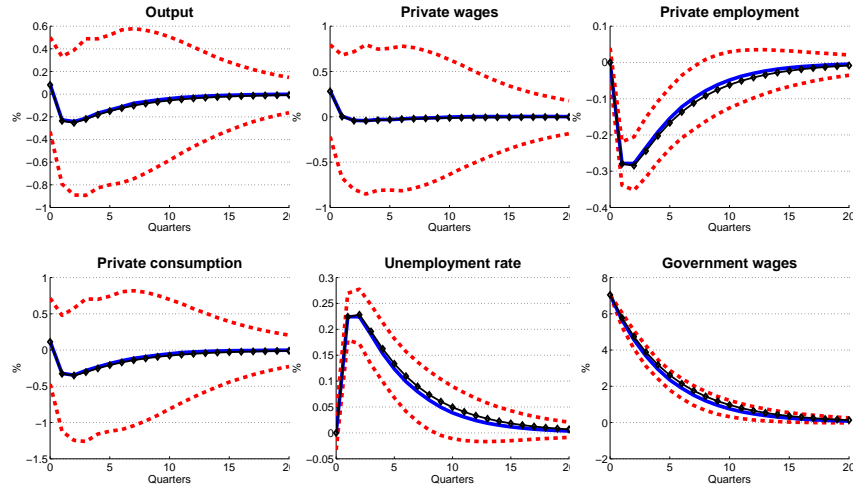
- PVM to global shock:

$$PVM_k^f = \frac{\sum_{j=0}^k \beta^j \hat{y}_j}{\sum_{q \in \{w,l,i,c,tr,t\}} \left(\sum_{j=0}^k \beta^j \hat{x}_j^q (x^q/y) \right)}$$

Note: The denominator is a weighted sum of responses of expenditures net of taxes to a global shock.

E   Estimation of government components shocks with simulated data

Figure 12: Theoretical and estimated impulse responses to a government wage shock
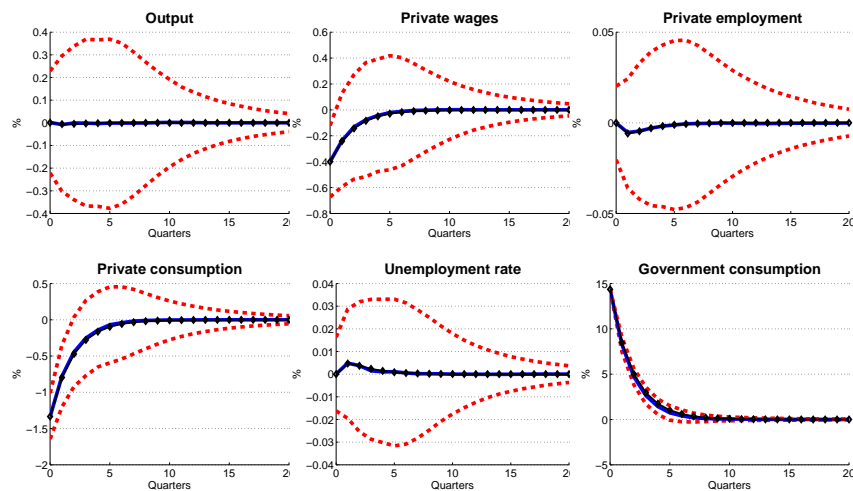

Notes: Response to a 1 percent of GDP wage shock: VAR response (solid line), VAR error bands (dash line) and theoretical impulse response (dotted line).

Figure 13: Theoretical and estimated impulse responses to a government employment shock
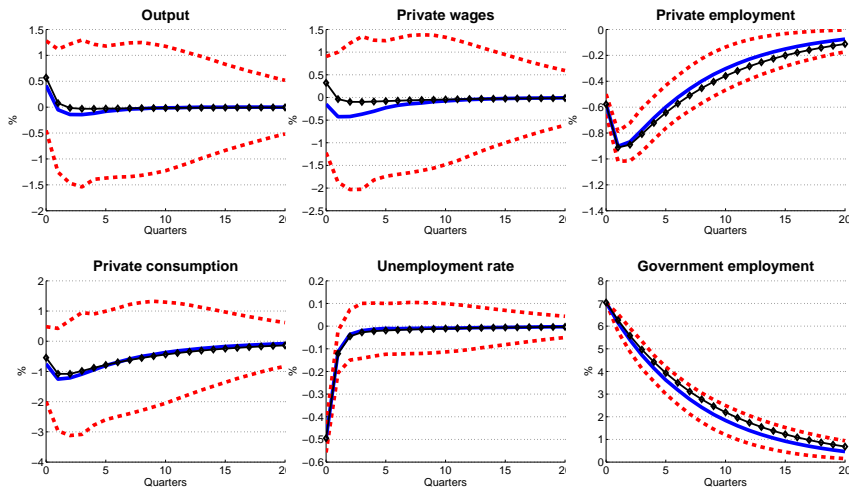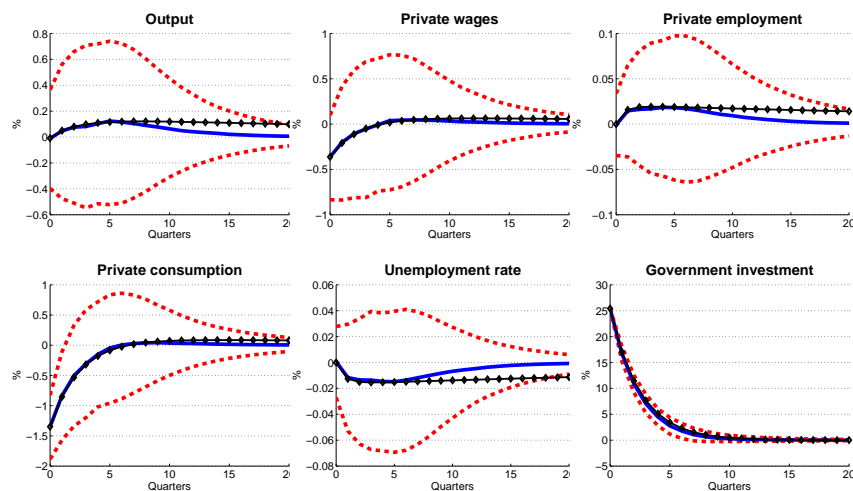

Notes: Response to a 1 percent of GDP employment shock: VAR response (solid line), VAR error bands (dash line) and theoretical impulse response (dotted line).

Figure 14: Theoretical and estimated impulse responses to a government consumption shock

Notes: Response to a 1 percent of GDP consumption shock: VAR response (solid line), VAR error bands (dash line) and theoretical impulse response (dotted line).

Figure 15: Theoretical and estimated impulse responses to a government investment shock

Notes: Response to a 1 percent of GDP investment shock: VAR response (solid line), VAR error bands (dash line) and theoretical impulse response (dotted line).