Unemployment Fiscal Multipliers[*]

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Abstract

We estimate the effects of fiscal policy on the labor market in US data. An increase in government spending of 1 percent of GDP generates output and unemployment multipliers respectively of about 1.2 per cent (at one year) and 0.6 percentage points (at the peak). Each percentage point increase in GDP produces an increase in employment of about 1.3 million jobs. Total hours, employment and the job finding probability all rise, whereas the separation rate falls. A standard neoclassical model augmented with search and matching frictions in the labor market largely fails in reproducing the size of the output multiplier whereas it can produce a realistic unemployment multiplier but only under a special parameterization. Extending the model to strengthen the complementarity in preferences, to include unemployment benefits, real wage rigidity and/or debt financing with distortionary taxation only worsens the picture. New Keynesian features only marginally magnify the size of the multipliers. When complementarity is coupled with price stickiness, however, the magnification effect can be large.

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1 Introduction

The strong response of fiscal policy to the financial crisis of 2007-08 has ignited a lively debate on the size (and sometimes even the sign) of fiscal policy multipliers. Much of the attention in policy circles has focused on the ability of government spending increases and tax cuts to boost output and to reduce the unemployment rate. For instance, the background analysis to the American Recovery and Reinvestment Act (ARRA) (see, e.g., Romer, 2009) is explicit in its emphasis on the ability of the fiscal stimulus to "generate jobs".[1] Despite this emphasis on labor markets in policy circles, the debate on fiscal policy in the research community has focused instead largely on the size of the GDP and consumption multipliers of government spending.[2] Much less attention has been devoted to the qualitative and the quantitative implications of fiscal policy for the unemployment rate and the labor market in general.

Our goal in this paper is twofold. First, to provide an empirical estimate of both the output and the unemployment multipliers of government spending in US data, focusing in more detail on the transmission of fiscal policy to the labor market. Thus, we investigate the effects on variables such as labor market tightness (the ratio of vacancies to unemployment), the job finding probability, the separation rate, the extensive and intensive margins of work (respectively, employment and hours per worker), labor force participation, and the real wage.

The second goal is to provide a theoretical framework that we can use to begin interpreting these results. To this end, we start by incorporating search and matching frictions à la Mortensen and Pissarides (1995) in a dynamic general equilibrium real business cycle model, along the lines of a recent literature pioneered by Shimer (2005) and Hall (2005a).[3] In this environment, we study

[1] According to Romer (2009, pag.2): "*The President gave a very concrete metric: he wanted a program that would raise employment relative to what it would be in the absence of stimulus by 3 to 4 million by the end of 2010*".

[2] A non-exhaustive list of papers in this literature includes Blanchard and Perotti (2002), Galí, López-Salido and Vallés (2007), Perotti (2007), Ravn, Schmitt-Grohé and Urîbe (2008), Ramey and Shapiro (1998), Burnside, Eichenbaum, and Fisher (2004), Barro and Redlick (2009), Davig and Leeper (2009), Hall (2009), Nekarda and Ramey (2009) and Ramey (2009). Hall (2009), Cogan, Cwik, Taylor and Wieland (2009), and various IMF and OECD publications provide useful comparisons of the multipliers estimated through various methodologies.

[3] See also Hagedorn and Manowskii (2008). This literature has exclusively focused on the effects of technology shocks. Pioneering examples of models introducing labor search and matching frictions within an RBC framework are Merz (1995) and Andolfatto (1996). Those studies, however, do not analyze fiscal policy.

the building blocks of the effects of government spending shocks on hiring, (un)employment and output. We also study in detail the role of additional features such as: (i) the complementarity between consumption and employment; (ii) the role of the wealth effect and of the elasticity of labor supply; (iii) the role of real wage rigidity, distortionary taxation and government debt financing. We then study how New-Keynesian features such as imperfect competition and time-varying markups (resulting from nominal price rigidity) can interact with labor search frictions in affecting the size of the unemployment and output fiscal multipliers.

Our main results on the empirical side can be summarized as follows. First, in response to an increase in government spending normalized to 1 percent of GDP, we estimate an output multiplier well above one, in the range of 1.2-1.5 (at one-year and two-year horizon respectively); and an unemployment rate multiplier of about -.6 at peak (in absolute percentage points). Second, hours and employment (the extensive margin) also rise significantly, with a peak response of about 1.5 percent, whereas hours per employed individual (the intensive margin) do not change significantly. Third, the job finding probability and the separation rate both respond significantly. Fourth, the real product wage rises by about 2.5 percent, whereas the markup falls by about 1.5 percent. The responses of both variables, however, are not very precisely estimated.

On the theoretical side, we start by showing that a baseline real model with search and matching frictions has fundamental difficulties in matching the estimated sizes of the unemployment and output multipliers. A value of the former that matches the estimated multiplier can be obtained only if a key parameter, the average relative value of non-work to work activities, is calibrated to be in the high range of available estimates. In our model, such parameter governs the elasticity of the hiring rate to changes in the marginal utility of wealth. Interestingly this parameter affects also the elasticity of the hiring rate to variations in the marginal product of labor, and is therefore of critical importance also for the quantitative effects of technology shocks on the unemployment rate (see Shimer, 2009, and Hagedorn and Manowski, 2008). However, even when the value of this parameter is calibrated to be in the high range, so as to roughly match the size of the unemployment multiplier of government spending estimated in the data, the model clearly delivers an output multiplier well below the estimated one.

A recent literature shows that wage rigidity magnifies the effects of technology shocks on the unemployment rate (Hall, 2005a, Shimer, 2005, Gertler and Trigari, 2008). We show that in our model real wage rigidity actually *decreases* the unemployment multiplier of government spending. Similarly, a higher degree of complementarity between consumption and employment tends to dampen the unemployment multiplier. Other modelling features that strengthen the realism of the model, such as the presence of a non-leisure value of being unemployed (such as unemployment benefits or home production) and/or debt financing with distortionary taxation, all contribute to *reducing* the unemployment and output multipliers of our baseline model.

We then introduce imperfect competition and nominal price rigidity. These features introduce a new channel of fiscal policy: countercyclical variations in the present value of markups, which tend to boost the hiring rate. Within this context we obtain two main results. First, a search and matching model augmented with NK features can magnify both the output and unemployment multipliers, but still delivers a size of the output multiplier largely below 1. Second, unlike the baseline case with flexible prices and perfectly competitive goods markets, a sufficiently high degree of complementarity, coupled with price stickiness, can generate a crowding-in of private consumption, and significantly boost the output multiplier.

Burnside, Eichenbaum and Fisher (2004) (BEF henceforth) is an earlier attempt to investigate, both empirically and theoretically, the implications of changes in government spending for the labor market. That study differs from ours in two dimensions. First, the empirical methodology: while BEF employ a dummy-based narrative approach to identify exogenous innovations to government spending (and defense spending in particular), we adopt a structural VAR approach based on recursive ordering. Second, BEF analyze their results through the lens of a real business cycle model with perfect labor markets, whereas labor search frictions are at the heart of our model. Recent important investigations of the effects of fiscal policy are also Ramey (2009), which we discuss extensively below, and Nekarda and Ramey (2009), who study the response of markups to government spending shocks using input-output tables.[4]

The outline of this paper is as follows: Section 2 describes the results from the empirical analysis

[4]See Perotti (2007) for an earlier application of this methodology to the same issue.

and provides a more general discussion on the methodologies that have been used in the literature to estimate the effects of fiscal policy. Section 3 presents the baseline model with search and matching frictions and government spending. Section 4 provides the main intuition for the channels through which government spending affect hiring and (un)employment. Section 5 presents the dynamic effects of government spending shocks within a calibrated version of the model. Section 6 extends the baseline model along a number of dimensions to assess the robustness of the quantitative results and to highlight additional mechanisms. Section 7 introduces the most relevant deviation from the baseline model by adding monopolistic competition and price stickiness, thus introducing an additional channel through which government spending affects hiring. Finally, section 8 concludes.

2 Empirics

2.1 Identification and results

To investigate the effects of fiscal policy on labor market variables we estimate a VAR. We identify government spending shocks on the basis of the approach of Blanchard and Perotti (2002): assuming that there are decision and implementation lags of at least three months, government spending cannot react to output and other shocks within a given quarter, hence in quarterly data government spending is predetermined. We then identify government spending shocks via a Choleski decomposition with government spending as the first variable. We discuss this approach in the next subsection.[5]

Our benchmark specification includes the following variables: the log of real per-capita government consumption (i.e., current government spending on goods and services), the log of real per-capita GDP, the log of real per-capita private consumption of nondurables and services, the nominal interest rate on 3-month T-bills, and the average marginal income tax rate from Barro and Redlick (2009); to this fixed set of variables we add one or two labor market variables in turn. The sample is 1954:1 - 2006:4. The end date is dictated by the availability of the average marginal

[5] We choose to abstract from the analysis of the effects of government investment and/or taxation. These are for instance an important component of the recent ARRA program in the US. Our goal is however not to provide a quantitative assessment of the impact of that program.

income tax rate; the initial date avoids the turbulent (from a fiscal policy point of view) years between 1945 up to the Korean War. The VAR also includes a constant and a time trend. To partially address the issue of anticipated fiscal policy, we also include lags 0 to 4 of each of three dummy variables, taking values of 1 on each of the three "Ramey - Shapiro" war dates included in our sample: 1965:1, 1980:1 and 2001:4.[6]

In the first specification the labor market variables are the logs of total civilian employment and total civilian hours, both divided by the civilian non-institutional population aged 16 to 64.[7] Figure 1 illustrates the main results. The responses of government spending and private consumption are expressed as percentage points of GDP; the initial shock to government spending is normalized to 1 percentage point of GDP. The figure displays the point estimate of the response, the median response out of 1000 replications, and two-standard error bands, corresponding to the 25th and 975th replication at each horizon.[8]

GDP and private consumption both rise, with peak responses at about 1.6 and .7 percentage points of GDP, respectively, after about two and a half years; at peak, both responses are significant at the 95 percent confidence level. Employment and hours also rise significantly, with peak responses of about 1.5 percent, again after about 10 quarters. As a result, the average number of hours per employed individual does not change significantly.

In the next specification we add the log of total unemployment and the log of the civilian labor force (both divided by population) to the fixed set of variables; the first three panels of Figure 2 (on the first row) display their responses, as well as the implied response of the unemployment rate.[9]

[6] See Ramey and Shapiro (1998). Ramey (2009) argues that, because fiscal policy is often anticipated, the Ramey - Shapiro dummy dates help predict VAR shocks; by construction, our shocks are orthogonal to the Ramey - Shapiro dummies up to 4 lags. Rossi and Zubairy (2009) also include these war dummies, but do not show impulse responses based on this specification.

[7] These data were assembled by Valerie Ramey based on published and unpublished data from the BLS, and kindly made available to us by the author. Results with total (including military) employment and hours are nearly identical.

[8] The standard errors were computed using the MONTEVAR routine in RATS. Much of the existing literature on fiscal policy VARs has used one-standard error bands (a notable recent exception is Ramey, 2009); it is quite possible that this tradition was initiated by Blanchard and Perotti (2002). Be as it may, we believe that this was a mistake, and that there is no reason to use non-standard standard error bands. Thus, in this paper we display only two-standard error bands.

[9] The response of the unemployment rate is constructed as the response of the log of total unemployment less the response of the log of the labor force, multipied by the average unemployment rate over the sample.

Unemployment falls, with a peak of about 10 percent again after 10 quarters, while the labor force does not move significantly. As a result, the unemployment rate falls by about .6 percentage points after 10 quarters.

In the third specification, we add both the logs of vacancies (measured by the Conference Board help-wanted advertising index) and of total unemployment, both as shares of the population aged 16 to 64, and calculate tightness as the differences of these two responses. Vacancies (first panel of the second row) increase substantially, by about 12 percent at peak (the standard deviation of the log change of vacancies is 34 percent). Combined with a decrease in unemployment which is only slightly smaller in absolute value, this delivers an increase in labor market tightness by almost 20 percent, with a peak slightly later than 10 quarters. The response of tightness is marginally insignificant at the 95 percent confidence level.

The next panels display the responses of the job finding probability and of the separation rate, each added in turn to the fixed set of variables. Both variables are calculated from data on unemployment and short-term unemployment as in Shimer (2005). The job finding probability increases, by about 3 percentage points at peak; the separation rate falls by about .12 percentage points at peak.[10] Both responses are just about significant at peak.

The last two panels display the responses of the real product wage and of the markup in manufacturing. The former increases by about 2.5 percent after about two years, and returns to trend very slowly. The latter falls by about 1 percent, but it is not estimated precisely.

Table 1 displays a few multipliers for GDP (from the specification with employment and hours as labor market variables) and the unemployment rate (from the specification with labor force and total unemployment as labor market variables; results from a specification with the unemployment rate as labor market variable are nearly identical). The first two columns display the actual responses, or the multipliers relative to the initial government spending shock, which is normalized to 1 percentage point of GDP. The next two columns display the cumulative multipliers. The cumulative GDP multiplier at horizon X is computed as the cumulative percentage change in GDP after X

[10] The average values of these variables over the sample are 45.4 percent and 3.4 percent, with standard deviatiosn of 6.5 and .5 percent, respectively.

quarters, divided by the cumulative change in the government spending, expressed in percentage points of GDP, at the same horizon. The unemployment multiplier is computed as the cumulative response of the unemployment rate after X quarters divided by the same denominator.

After the second quarter, the GDP responses and the GDP cumulative multipliers are very similar: both are well above 1, and on the high side relative to those estimated in the literature. The unemployment rate responses and cumulative multipliers are also similar, ranging between between -.4 and -.6 at year 2.

Table 1: Estimated Multipliers

	Responses		*Cumulative*	
Horizon	$\frac{\Delta Y}{\Delta G}$	$\frac{\Delta u}{\Delta G}$	$\frac{\Sigma\Delta Y}{\Sigma\Delta G}$	$\frac{\Sigma\Delta u}{\Sigma\Delta G}$
2 quarters	.68	-.16	1.00	-.15
1 year	1.21	-.43	1.16	-.31
2 years	1.54	-.54	1.50	-.43
peak	1.60	-.64	-	-

2.2 Discussion

The identification of government spending shocks has been the subject of a lively debate in recent years.[11] This debate has implications that go well beyond the econometrics, because different identification schemes can lead to very different conclusions about the responses of key variables to fiscal shocks. To summarize why this is important, note that while virtually all models imply that a surprise increase in government spending has positive effects on GDP (if taxes are not too distortionary), in neoclassical models typically private consumption and the real wage decline, while the opposite can occur in new-keynesian models. Hence, even though in this paper we do not focus on the response of private consumption *per se*, clearly the responses of variables other than GDP are important in assessing the mechanism underlying the channels of operation of fiscal policy on the labor market.

[11] See Perotti (2007) and Ramey (2009) for a summary of the issues.

Some of our results appear *prima facie* consistent with new-keynesian models. However, one potential problem with our approach to identification is that government spending changes that appear unpredictable to the econometrician might well have been anticipated by the private sector: the resulting estimated impulse responses may be biased. The only way to assess this issue is to introduce actual forecasts, as Romer and Romer (2009) do for taxes. Ramey (2009) constructs a detailed time series of revisions of expected future defense spending, from 1939 onward; she finds a positive effect of shocks to the revision of defense spending forecasts on GDP and hours, and a negative effect on the consumption of nondurables and durables; these results seem more consistent with a neoclassical model (although the manufacturing wage response is positive).

This approach is potentially fruitful, as one can argue quite plausibly that the changes in defense spending identified with this method were exogenous. However, we like many others, are skeptical that one can learn much about the effects of fiscal policy on consumption during a period, like WWII, when nondurables were rationed and the production of many durables for civilian purposes was effectively shut down for several years; similarly, it is difficult to see what one can learn regarding the effects on employment and hours when the draft and patriotism played such a large role in labor markets. If one starts the sample in 1947, Ramey (2009) shows that the basic qualitative responses survive, although the standard errors become larger.[12] However, these results hinge, for the post-war period, entirely on the Korean War; if one starts the sample in 1954, there is no evidence of a decline in private consumption, and the standard errors become extremely large. In fact, the results for the post-war period hinge entirely on just two quarters of the Korean War, 1950:3 and 1950:4, which were very special in several respects;[13] it is enough to exclude these two quarters for the impulse responses of durable and nondurables consumption to become positive or flat, even though with very wide standard error bands.

Ramey also uses surveys of professional forecasters over the sample 1981:3 - 2008:4 and finds negative responses of private consumption (and now also of GDP) to expectation errors. Besides

[12] Standard errors calculated by the authors: Ramey (2009) does not report standard errors for the post-WWII sample.

[13] See Perotti (2010) for a discussion of restrictions in place over these and subsequent quarters, like Regulation X and Regulation W.

displaying large standard errors, these estimates too are extremely unstable: it is enough to drop the last two years of the sample (2007 to 2008) for the effects on GDP and consumption to turn positive. In addition, Perotti (2010) shows that these shocks are not derived from expectations that are effectively in the information set of the private sector; if one calculates the correct revisions to the forecasts of future government spending, as actually held by the private sector, then one finds positive effects of government spending shocks on GDP, consumption and employment.[14]

Ultimately, whether anticipation effects are important is an empirical issue. Note that for individuals that are liquidity constrained anticipated fiscal policy is irrelevant; and indeed the estimates of Johnson, Parker and Souleles (2006) based on the 2001 tax rebate suggest that about two-thirds of predictable changes in taxes and transfers are translated into consumption in the quarter they are received and the next. Econometrically, Mertens and Ravn (2009) show that, for a large class of models, a simple Choleski decomposition might deliver nearly correct impulse responses even if shocks are anticipated by the private sector.

We realize, of course, that all identification schemes are questionable. We see the empirical evidence we have presented as mostly a motivation for the theoretical analysis below. For those who are unconvinced by our identification scheme, we think the best way to interpret the rest of this paper is to see it as a study of the building blocks of the effects of fiscal policy in a model with search and matching frictions, with increasing levels of complications.

3 The model

There is a continuum of infinitely-lived workers and a continuum of infinitely-lived identical firms, each of measure one. Each firm employs n_t workers in the current period. To attract new workers for the current period of operation it posts v_t vacancies. Posting vacancies is costly: we assume that hiring costs are linear in the number of vacancies. The total number of unemployed workers searching for a job is $u_t = 1 - n_{t-1}$.[15] Following convention, we assume that the aggregate number

[14] However, inferences from these estimates are made difficult by other issues discussed in Perotti (2010).

[15] All workers unemployed at the beginning of the period, u_t, search for a job, that is, we abstract from labor force participation choices.

of new hires or "matches", m_t, is a Cobb-Douglas function of unemployed workers and vacancies, $m_t = \gamma_m u_t^{\gamma} v_t^{1-\gamma}$, where the parameter γ_m reflects the efficiency of the matching process. The current probability that a firm fills a vacancy, q_t, is given by $q_t = m_t/v_t = \gamma_m \theta_t^{-\gamma}$, where $\theta_t \equiv v_t/u_t$ is labor *market tightness*, the ratio of vacancies, v_t, to searching unemployed workers, u_t. Similarly, the probability an unemployed worker finds a job, p_t, is given by $p_t = m_t/u_t = \gamma_m \theta_t^{1-\gamma}$. Both firms and workers take q_t and p_t as given. Finally, each firm exogenously separates from a fraction $1-\rho$ of existing workers each period, where ρ is the probability a worker "survives" with the firm until the next period.

3.1 Firms

Every period, the representative firm produces output, y_t, using capital, k_t, and labor, n_t, according to the following Cobb-Douglas technology $y_t = z k_t^{\alpha} n_t^{1-\alpha}$, where z is a common productivity factor. Capital is perfectly mobile across firms and there is a competitive rental market in capital.

Firms increase their current workforce n_t by posting vacancies v_t. The timing is as follows: each firm starts period t with n_{t-1} employed workers; at the beginning of the period, firms post v_t vacancies to attract new workers and $u_t = 1 - n_{t-1}$ workers search for jobs; the searching process leads to m_t new matches; then, a fraction $1-\rho$ of workers employed at $t-1$ is exogenously separated from each firm; separated workers cannot search until the following period; finally, newly formed matches, m_t, become productive within the same period and are not subject to separations until the following period. Total period-t workforce is then the sum of the number of last period's surviving workers, ρn_{t-1}, and new hires, $q_t v_t$:

$$n_t = \rho n_{t-1} + q_t v_t. \tag{1}$$

Let $\beta \Lambda_{t,t+1}$ be the firm's stochastic discount factor between period t and $t+1$, where β is the household's subjective discount factor and $\Lambda_{t,t+1}$ is defined below.[16] Let w_t be the real wage rate, $r_{k,t}$ the rental rate on capital and κ the per period cost of keeping a vacancy open. The firm's

[16] $\Lambda_{t,t+1}$ is the period-t price of a consumption claim contingent on history up and including time $t+1$, and traded at time t. See below for our assumptions on the structure of financial markets.

problem can be then written:

$$F\left(n_{t-1},k_t\right)=\max_{k_t,n_t}\left\{z_t k_t^{\alpha}n_t^{1-\alpha}-w_t n_t-\kappa v_t-r_{k,t}k_t+\beta E_t\left\{\Lambda_{t,t+1}F\left(n_t,k_{t+1}\right)\right\}\right\}, \tag{2}$$

subject to (1).

The first order condition for the choice of capital is

$$r_{k,t}=\alpha\frac{y_t}{k_t}, \tag{3}$$

equating the marginal product of capital to the rental rate.

Firms choose n_t by setting v_t. Taking the first order condition with respect to n_t, making use of the envelope condition to obtain $\partial F\left(n_{t-1},k_t\right)/\partial n_{t-1}$ and combining equations we obtain

$$\frac{\kappa}{q_t}=a_t-w_t+\rho\beta\mathbb{E}_t\left\{\Lambda_{t,t+1}\frac{\kappa}{q_{t+1}}\right\}, \tag{4}$$

where $a_t\equiv(1-\alpha)\,y_t/n_t$ is the marginal product of labor. Condition (4) equates the marginal cost of hiring a worker with the marginal benefit. The latter is given by a discounted stream of firm's expected future net earnings from the marginal worker.

For the purpose of the wage bargain it is useful to define $F_{n,t}$ as the value to the firm of having an additional worker at time t after new workers have joined the firm, i.e., after vacancy posting costs are sunk. Differentiating $F\left(n_{t-1},k_t\right)$ with respect to n_t taking v_t as given, using also the first order condition with respect to n_t to rearrange, one obtains

$$\frac{\kappa}{q_t}=F_{n,t}, \tag{5}$$

so that $F_{n,t}$ may be expressed as the discounted stream of expected future profits per worker:

$$F_{n,t}=a_t-w_t+\rho\beta\mathbb{E}_t\left\{\Lambda_{t,t+1}F_{n,t+1}\right\}. \tag{6}$$

3.2 Households

We use the "family" construct of Merz (1995). In particular, there is a representative household consisting of a continuum of individuals of mass one. The household pools incomes and allocates total consumption across members to maximize the sum of utilities. As in Shimer (2009), assume that the period-t utility function of a household member is $\left[c_{e,t}^{1-\sigma}\left(1+(\sigma-1)b\right)^{\sigma}-1\right]/(1-\sigma)$ if employed and $\left[c_{u,t}^{1-\sigma}-1\right]/(1-\sigma)$ if unemployed, where $c_{e,t}$ and $c_{u,t}$ denote consumption of the employed and unemployed members respectively, $b>0$ is the relative disutility of work, and $\sigma>0$ is a parameter that captures the degree of substitutability between consumption and leisure (with $\sigma=1$ utility is separable).

The household has a diversified ownership stake in firms which pays out profits π_t, and pays lump sum taxes to the government τ_t. The household may either consume (on average) c_t or accumulate capital k_t through investment i_t according to

$$k_{t+1}=(1-\delta)k_t+i_t(1-\phi_t), \tag{7}$$

where δ is the depreciation rate of capital, and ϕ_t is a function that captures adjustment costs on capital proportional to the rate of change in investment (as in Christiano *et al.*, 2005): $\phi_t \equiv \phi\left(\frac{i_t}{i_{t-1}}-1\right)$, with $\phi(\cdot)$ satisfying $\phi(1)=\phi^{'}(1)=0$ and $\phi^{''}(1)>0$ in the steady state.

Thus, the representative household faces a single period-by-period budget constraint of the form:

$$c_t+i_t+\mathbb{E}_t\left\{\Lambda_{t,t+1}B_{t+1}\right\}\leq w_t n_t+r_{k,t}k_t+B_t+\pi_t-\tau_t, \tag{8}$$

where $c_t=c_{e,t}n_t+c_{u,t}(1-n_t)$ is average consumption of employed and unemployed workers and B_t denotes the holding of real one period state contingent securities. Further, the household recognizes that household employment is determined by the flows of its members into and out of employment according to

$$n_t=\rho n_{t-1}+p_t\left(1-n_{t-1}\right), \tag{9}$$

where the household takes p_t as given.

By taking first order conditions with respect to $c_{e,t}$ and $c_{u,t}$ one can show (see Shimer 2009) that, in equilibrium, the household behaves as if it has intertemporal utility

$$\mathbb{E}_t\sum_{t=0}^{\infty}\beta^t\left(\frac{c_t^{1-\sigma}\left(1+(\sigma-1)bn_t\right)^{\sigma}-1}{1-\sigma}\right), \tag{10}$$

where β is the discount factor, subject to the same budget constraint as before.

Let H_t be the representative household lifetime utility. Then the household maximization problem may be expressed as

$$H\left(n_{t-1},k_t\right) = \max_{c_t,k_{t+1}} \left\{ \frac{c_t^{1-\sigma}\left(1+(\sigma-1)bn_t\right)^{\sigma}-1}{1-\sigma} + \beta\mathbb{E}_t\left\{H\left(n_t,k_{t+1}\right)\right\} \right\}, \tag{11}$$

subject to (8) and (9).

The first order necessary condition for consumption yields:

$$\lambda_t = \left(\frac{1+(\sigma-1)bn_t}{c_t}\right)^{\sigma}, \tag{12}$$

where λ_t is the marginal utility of wealth (i.e., the multiplier on the household's budget constraint). Equation (12) links the marginal utility of wealth to the marginal utility of consumption. The first order conditions for investment and capital read:

$$\varphi_t\left[1-\left(\phi_t+\frac{i_t}{i_{t-1}}\phi_{i,t}\right)\right] = 1-\beta\mathbb{E}_t\left\{\varphi_{t+1}\Lambda_{t,t+1}\left[\left(\frac{i_{t+1}}{i_t}\right)^2\phi_{i,t+1}\right]\right\}, \tag{13}$$

$$\varphi_t = \beta\mathbb{E}_t\left\{\Lambda_{t,t+1}\left[r_{k,t+1}+\varphi_{t+1}\left(1-\delta\right)\right]\right\}, \tag{14}$$

where φ_t is the shadow value of a unit of investment (the multiplier on (7)), $\phi_{i,t}$ is the derivative of $\phi(\cdot)$ with respect to i_t, and $\Lambda_{t,t+1} = \lambda_{t+1}/\lambda_t$.

Using the envelope condition for employment, we derive the marginal value to the household of having one member employed rather than unemployed, $H_{n,t}$, which is a determinant of the bargaining problem:

$$H_{n,t} = \lambda_t w_t - U_{n,t} + \beta\left(\rho - p_{t+1}\right)\mathbb{E}_t\left\{H_{n,t+1}\right\}, \tag{15}$$

where $U_{n,t}$ is the marginal disutility from work, given by

$$U_{n,t} = \sigma b\left(\frac{1+(\sigma-1)bn_t}{c_t}\right)^{\sigma-1}. \tag{16}$$

Non-separability in utility makes $U_{n,t}$ time-varying: with $\sigma = 1$, we have $U_{n,t} = b$.

Equation (15) indicates that the household's shadow value of one additional employed member (the left hand side) has three components: first, the increase in utility generated by having an additional member employed, given by the real wage expressed in utils; second, the decrease in utility from lower leisure, given by the marginal disutility of work; third, the continuation utility value, given by the contribution of a current match to next period household's employment.

3.3 Marginal value of non-work activity

Note that we can write $U_{n,t}$ as

$$U_{n,t} = \sigma b \lambda_t^{\frac{\sigma-1}{\sigma}}, \tag{17}$$

so that

$$H_{n,t} = \lambda_t (w_t - \omega_t) + \beta (\rho - p_{t+1}) \mathbb{E}_t \{H_{n,t+1}\},$$

where

$$\omega_t \equiv \frac{U_{n,t}}{\lambda_t} = \sigma b \lambda_t^{-1/\sigma} \tag{18}$$

is the current *marginal value of non-work activity.* Importantly, this value does not only capture the marginal value of leisure, but broadly the value of all non-market activities, including home production and unemployment benefits.

Notice that the elasticity of ω_t to the marginal utility of wealth is decreasing in σ:

$$\left| \frac{\partial \log \omega_t}{\partial \log \lambda_t} \right| = \frac{1}{\sigma}$$

In our context the effect of the marginal utility of wealth λ on the value of non-work activity will bear important implications for the transmission of fiscal policy.

3.4 Nash bargaining and reservation wages

Each period, the firm negotiates with the marginal worker over the surplus from the marginal match. We assume Nash bargaining so that the wage w_t is chosen to maximize the function $(H_{n,t})^\eta (F_{n,t})^{1-\eta}$, where $\eta \in (0, 1]$ reflects the workers' bargaining power.

The first order necessary condition for Nash bargaining is

$$\eta F_{n,t} = (1 - \eta) \frac{H_{n,t}}{\lambda_t}, \tag{19}$$

where $H_{n,t}/\lambda_t$ is the marginal benefit to the household of one additional employed worker, expressed in units of consumption goods. Nash bargaining implies that the worker and the firm receive a share of the surplus that is constant over time and determined by the relative bargaining power η. To see why, let $S_{n,t} \equiv H_{n,t}/\lambda_t + F_{n,t}$ denote the *total surplus* from a marginal match expressed in units of the consumption goods. Then using (19) it is easy to show that $H_{n,t}/\lambda_t = \eta S_{n,t}$ and $F_{n,t} = (1 - \eta) S_{n,t}$.

The size of the surplus, $S_{n,t}$, is related to the size of the *bargaining set*, i.e., the gap between the reservation wages: the minimum wage acceptable to the worker, $\underline{w}_t$, and the maximum wage acceptable to the firm, $\overline{w}_t$. More specifically, we have

$$S_{n,t} = \overline{w}_t - \underline{w}_t, \tag{20}$$

with

$$\overline{w}_t = a_t + \rho\beta\mathbb{E}_t \left\{\Lambda_{t,t+1} F_{n,t+1}\right\}. \tag{21}$$

$$\underline{w}_t = \omega_t - \beta\mathbb{E}_t \left\{(\rho - p_{t+1}) \Lambda_{t,t+1} H_{n,t+1}\right\}, \tag{22}$$

Intuitively, if the marginal value ω_t is higher, non-work activities become more attractive at the margin, and the household's minimum acceptable wage will rise. The household's reservation wage is then decreasing in the continuation value, for the household is willing to trade off a lower wage for a higher future continuation value from the match. Conversely, the firm will be willing to increase its maximum acceptable wage both if the current marginal product of labor is higher and its future expected continuation value is higher.

The bargained wage in turn is a weighted average of the bargaining set limits, with weight equal to the bargaining power:

$$w_t = \eta\overline{w}_t + (1 - \eta) \underline{w}_t, \tag{23}$$

where the higher is the worker's bargaining power η the closer is the wage to the firm's reservation wage and vice versa.

3.5 Surplus

Combining equations (6) and (15) with the Nash rule (19), we can write a recursive expression for the total surplus as follows:

$$S_{n,t} = a_t - \omega_t + \beta \mathbb{E}_t \left\{ (\rho - \eta p_{t+1}) \Lambda_{t,t+1} S_{n,t+1} \right\}. \tag{24}$$

The surplus derived from the match depends on two terms: first, the current gap between the marginal product of labor and the marginal value of non-work activities; second, the future surplus from the match, conditional on the same match surviving next period, net of the worker's future surplus from a match in case of break up, conditional on finding a job.

Next, using (5) and the fact that bargaining implies $F_{n,t} = (1 - \eta) S_{n,t}$, one can express the hiring condition as

$$\frac{\kappa}{\gamma_m} \theta_t^{\gamma} = (1 - \eta) S_{n,t} \tag{25}$$

Equation (25) shows that that the firm's hiring rate depends directly on the size of the surplus derived from the match. Finally, combining equations it is useful to rewrite (25) in terms of market tightness θ_t as follows:

$$\kappa \gamma_m^{-1} \theta_t^{\gamma} = (1 - \eta)(a_t - \omega_t) + \beta \mathbb{E}_t \left\{ (\rho - \eta p_{t+1}) \Lambda_{t,t+1} \kappa \gamma_m^{-1} \theta_{t+1}^{\gamma} \right\}. \tag{26}$$

Notice that for $\kappa \to 0$ the previous expression reduces to the standard condition equating the current marginal product of labor to the current marginal value of non work activity. The same occurs if the efficiency of the matching process improves, i.e., $\gamma_m \to \infty$. In both cases the model with search and matching frictions converges to the frictionless economy without matching frictions.

3.6 Government policy and resource constraint

Lump sum taxes adjust to balance the government budget constraint:

$$\tau_t - g_t = 0, \tag{27}$$

where government spending, g_t, follows the exogenous stochastic process:

$$\log g_t = (1 - \rho_g) \log g_y + \rho_g \log g_{t-1} + \varepsilon_{g,t}, \tag{28}$$

with $\varepsilon_{g,t}$ i.i.d. and where $g_y = g/y$ denotes the steady state share of government spending in output.

By combining (27) with (8), and recalling that in equilibrium $B_t = 0$ for all t, we obtain the aggregate resource constraint:

$$y_t = c_t + g_t + i_t + \kappa v_t. \tag{29}$$

4 Model properties

In order to better inspect the mechanism driving the short-run effect of variations in government purchases on the labor market, it is useful to take a log-linear approximation of (26) and write

$$\widehat{\theta}_t = \left(\frac{1-\psi}{\gamma}\right)\left(\frac{1}{1-\overline{\omega}}\widehat{a}_t - \frac{\overline{\omega}}{1-\overline{\omega}}\widehat{\omega}_t\right) - \frac{\psi}{\gamma}\widehat{r}_t + \beta\left(\frac{\rho\gamma - \eta p}{\gamma}\right)\mathbb{E}_t\left\{\widehat{\theta}_{t+1}\right\}, \tag{30}$$

where $\psi \equiv \beta(\rho - \eta p) > 0$, and a hat denotes the percentage deviation of a variable from its steady state value (denoted without superscript). In the above expression, $\widehat{r}_t \equiv -\mathbb{E}_t\left\{\widehat{\Lambda}_{t,t+1}\right\}$ is the real interest rate, and $\overline{\omega}$ is the steady-state *relative* value of non-work to work activity, given by

$$\overline{\omega} \equiv \frac{\omega}{a} = \frac{\sigma b \lambda^{-1/\sigma}}{a}. \tag{31}$$

Notice that $\overline{\omega}$ is increasing in b, the relative disutility of work, and decreasing in λ, the marginal utility of wealth. We will show below that the value of the parameter $\overline{\omega}$ is critical in determining the size of the government spending multipliers, both for output and unemployment.

Equation (30) reveals that variations in government spending affect the surplus and, in turn, the hiring rate via three channels: (i) a *marginal value of work* channel, (ii) a *real interest rate* channel, and (iii) a *capital accumulation* channel.

The intuition works as follows. Consider a temporary rise in the present value of government spending, and therefore of taxes. This induces a tightening of the household's budget constraint, captured by a rise in λ_t, and lowers the value of non-working activity ω_t, which raises the surplus $S_{n,t}$. In turn, this raises $F_{n,t}$ and the hiring rate θ_t.

There are two key parameters that determine the size of this effect. This can be seen by extrapolating the term $[\overline{\omega}/(1-\overline{\omega})]\,\widehat{\omega}_t$ from expression (30). In particular we can write:

$$\frac{\overline{\omega}}{1-\overline{\omega}}\widehat{\omega}_t = -\frac{\overline{\omega}}{1-\overline{\omega}}\frac{1}{\sigma}\widehat{\lambda}_t. \tag{32}$$

Hence a rise in the shadow value of wealth lowers the marginal value of non-work activities ω_t with elasticity $1/\sigma$. In turn, a variation in ω_t affects the surplus, and thus tightness, via an elasticity that depends on $\overline{\omega}$.

The channel affecting the marginal value of work competes, however, with two additional, and counter-acting, channels. For one, since the shock is temporary, the rise in the shadow value of wealth pushes the equilibrium real interest rate up. In turn, this produces a fall in the discounted marginal benefit from new vacancies (for given wages and given marginal product of labor): this effect discourages hiring. The presence of capital accumulation adds an additional effect. A lower expected future capital stock (due to the fall in current investment) implies a lower marginal product of labor, thereby further discouraging hiring.

Equation (30) reveals three key differences between a model with labor search frictions and a standard neoclassical growth model. First, while in the latter the employment decision is taken, in each period, to equate the marginal product of a new worker to the marginal disutility of labor (normalized by the marginal utility of consumption), in our model, due to the presence of hiring frictions, the hiring rate is a forward-looking variable. Second, the presence, in our context, of a real interest rate effect - that is absent in the neoclassical growth model - and follows from the hiring decision being forward-looking. Third, the presence of a "marginal value of non work effect", that differs from a standard wealth effect on labor supply. Our model, in fact, does not feature an endogenous margin in labor hours. Hence the value of non-work activity captures the cost in terms of the joint surplus of increasing the number of employed members at the margin.

The role of the relative value of non-work activities As suggested above the effect of variations in government spending on market tightness is larger the higher is $\overline{\varpi}$, the average value of non-work *relative* to work activities. When the (steady-state) marginal value of work activities, a, is close to the (steady-state) marginal value of non-work activities, $\sigma b \lambda^{-1/\sigma}$, the average joint surplus from the marginal match is small. Since firms obtain a constant share $1-\eta$ of the joint surplus, the average profit from hiring an additional worker is also small. In this case, changes in either the marginal product of labor or in the marginal value of time will have a high leverage on the profit from the marginal match. Even small changes in the marginal value of time, induced by small changes in government spending through small changes in the marginal utility of wealth, will cause a very large change in firms' profits in percentage terms, and thus induce very large changes in firms' hiring activity.

The role of the average relative value of non-work to work activity, $\overline{\varpi}$, has been emphasized in the literature initiated by Shimer (2005) focusing on the ability of the search and matching model to generate a large response of hiring activity to productivity shocks. Not surprisingly, a high value of $\overline{\varpi}$ is key for the result in Hagedorn and Manowskii (2008) who argue that a standard Mortensen and Pissarides type of model (driven only by productivity shocks) can replicate the volatility in (un)employment observed in the data absent wage rigidity.

To summarize, a large steady-state value of non-work relative to work activity reduces the average surplus and thus makes it easier to generate large labor market fluctuations to any shock affecting the surplus. In other words, employment is highly elastic to driving forces. This is also equivalent to assuming that employment is strongly wage elastic: even a small variation in the real wage can generate large fluctuations in equilibrium (un)employment. One can think of $\overline{\varpi}$ as a key determinant of the elasticity of labor supply at the extensive margin, playing a similar role to the Frisch elasticity of labor supply at the intensive margin. However, while the latter is a preferencebased parameter, which household data indicate to be small (see Hall, 2009, for a survey), the former connects employment and the wage *in equilibrium* and depends on a number of parameters in a convoluted way.

5 Dynamic simulations

In this section we simulate a quantitative version of the model. Our goal is to quantify the size of the unemployment and output multiplier in the baseline version of the model when all the channels of variations in government spending are at work: the marginal value of time channel, the real interest rate channel and the capital accumulation channel. To this end a thorough discussion of our calibration strategy is crucial.

5.1 Calibration

The job finding rate in the US is typically quite high, so unemployed workers on average find a job within a quarter. To properly capture this feature of the data, we choose to calibrate the model at a monthly frequency.

There are twelve parameters to which we need to assign values. Three are conventional in the business cycle literature: the discount factor, β, the depreciation rate, δ, and the share parameter on capital in the Cobb-Douglas production function, α. We use conventional values for all these parameters: $\beta = 0.99^{1/3}$, $\delta = 0.025/3$, $\alpha = 1/3$. We assume that the investment adjustment cost function is convex and given by $\phi(\cdot) \equiv (\eta_k/2)(i_t/i_{t-1} - 1)^2$, and choose $\eta_k = 3.24$ following the estimates of Christiano et al. (2005). Note that in contrast to the frictionless labor market model, the term $1-\alpha$ does not necessarily correspond to the labor share, since the latter will in general depend on the outcome of the bargaining process. However, because a wide range of values of the bargaining power imply a labor share just below $1-\alpha$, here we simply follow convention by setting $1-\alpha = 2/3$.[17] We set the value for the government spending autoregressive parameter, $\rho_g = 0.9^{1/3}$, in line with our VAR estimates.

[17] In our baseline calibration, for example, $1-\alpha$ equals 0.6667 and the labor share 0.6618.

There are five parameters that are specific to the search and matching framework: the job survival rate, ρ, the efficiency parameter in matching, γ_m, the elasticity of matches to unemployment, γ, the bargaining power parameter, η, and the hiring cost parameter, κ; and two parameters that describe preferences: the parameter governing the degree of complementarity in consumption and labor, σ, and the parameter capturing distaste for work, b.

We choose the average monthly separation rate $1 - \rho$ following Shimer's (2005) calculations, according to which jobs last about two years and a half. Therefore, we set $\rho = 1 - 0.035$. We choose the elasticity of matches to unemployment, γ, to be equal to 0.5, the midpoint of values typically used in the literature. This choice is within the range of plausible values of 0.5 to 0.7 reported by Petrongolo and Pissarides (2001) in their survey of the literature on the estimation of the matching function. To maintain comparability with much of the existing literature, we impose symmetry in bargaining and set η to be equal to 0.5. This choice also guarantees that the Hosios (1990) condition for efficiency is satisfied. We then set the i) the adjustment cost parameter, κ, ii) the disutility of work parameter, b, and iii) the efficiency parameter in matching, γ_m, to target i) the average job finding probability, p, ii) the ratio of the marginal value of time to the marginal product of labor, $\overline{\omega}$, and iii) the average value of market tightness, θ. We choose $p = 0.45$ to match recent estimates of the U.S. average monthly job finding rate (Shimer, 2005). We set $\theta = 0.5$, close to the values that can be obtained from measures of vacancies in JOLTS. Note however that the choice of θ implies a normalization.[18]

[18] Doubling the target for average tightness θ will reduce in half the hiring cost parameter κ, reduce in half the job filling probability q, and double the average vacancies v, without affecting the dynamics of the model.

Table 2. Baseline calibration

Discount factor	β	$0.99^{1/3}$
Capital depreciation rate	δ	$0.025/3$
Share of capital in prod. function	α	0.33
Investment adjustment cost parameter	η_k	3.24
Gov spending autoregressive parameter	ρ_g	$0.9^{1/3}$
Survival rate	ρ	0.965
Elasticity of matches to unemployment	γ	0.5
Bargaining power parameter	η	0.5
Complementarity parameter	σ	1
Matching function constant	γ_m	set to target $\theta = 0.5$
Adjustment cost parameter	κ	set to target $p = 0.45$
Unemployment flow value	b	set to target $\overline{\omega} = 0.9$

Perhaps most controversial is the choice of $\overline{\omega}$. In the baseline calibration we set $\overline{\omega} = 0.9$ in the high side of the range of sensible values, but we provide a discussion at the end of the section. We calibrate the complementarity parameter σ to 1, which corresponds to the separable utility case, but we explore the role of non separability further below.

Our baseline parameterization is summarized in Table 2. Given the crucial role of the parameterization of $\overline{\omega}$, we discuss its interpretation within the model and we describe the values that have been adopted elsewhere in the literature. Notice, first, that our calibration strategy implies that larger values for $\overline{\omega}$, other things equal, correspond to smaller search frictions. To see this, write the steady state version of equation (26),

$$\kappa \gamma_m^{-1} \theta^{\gamma} = \frac{(1-\eta)(a-\omega)}{1-\beta(\rho-\eta p)},$$

which equates the firm expected cost of hiring a worker to the firm's share of the surplus from the match. For given choices of β, η, ρ and p, when the marginal value of time is closer to the value of work, i.e., when $\overline{\omega} = \omega/a$ is larger, the surplus from the match is smaller and so is the share accruing to the firm. This implies that in equilibrium the cost of hiring a worker or, equivalently, the size of search frictions must also be smaller.[19]

[19] In the model, search frictions can become smaller because either κ decreases or γ_m increases. Our calibration strategy implies that larger value of $\overline{\omega}$ results in a lower value of κ.

There has not been much consensus in the recent literature on how to calibrate the value of non work to work activities or, alternatively, other measures of the size of search frictions. Shimer (2005) assumes that the value of non work activities (interpreted as only unemployment benefits) is far below what workers produce on the job and set $\overline{\omega}$ to 0.4. This view is shared by Hall (2005b), but is in stark contrast with Hagedorn and Manovskii (2008) who argue in favor of values of $\overline{\omega}$ close to 0.95. In subsequent work, Hall proposes intermediate values by interpreting the benefit from non work activities as reflecting not only unemployment insurance but also utility gains from leisure. Shimer (2009) refers to evidence in Hagedorn and Manovskii (2008) and Silva and Toledo (2008) on the wage cost of recruiting a new worker. He chooses to target a cost of recruiting a worker equal to 4 percent of a worker's quarterly wage. Others instead choose to target the share of total hiring costs on output. Andolfatto (1996), for example, targets a 1 percent share of recruiting expenditures to output.

Note that, for given values of β, η, ρ, α, and p, targeting the cost of hiring a worker in terms of wages, $(\kappa\gamma_m^{-1}\theta^{\gamma})/w$, or the share of total hiring costs to output, $\kappa v/y$, is equivalent to targeting $\overline{\omega}$, as implied by the following steady state relations:

$$\frac{\kappa\gamma_m^{-1}\theta^{\gamma}}{w} = \frac{(1-\eta)(1-\overline{\omega})}{(1-\rho\beta)[\eta+(1-\eta)\overline{\omega}]+\eta\beta p}$$

$$\frac{\kappa v}{y} = \frac{(1-\alpha)(1-\eta)(1-\overline{\omega})(1-\rho)}{1-\beta(\rho-\eta p)}$$

Using these relations and with the purpose of making comparison across papers, Table 3 considers four possible values for $\overline{\omega}$ and reports the implied values for both the cost of hiring a worker in terms of quarterly wages and the ratio of hiring costs to output. The table shows that setting $\overline{\omega}$ to 0.4 implies that hiring a worker uses about 40 percent of a worker's quarterly wage (ten times as large as the value in Shimer, 2009). It also implies that the share of total recruiting costs on output is as large as 2.7 percent. When $\overline{\omega}$ is increased to 0.9, then hiring a workers takes about 6.5 percent of the quarterly wage and the share of overall hiring costs to output is 0.44 percent. This case is closer to the calibration in Shimer (2009).

Table 3. Implications of different values for $\overline{\omega}$

Relative value of non work activity to work activity	$\overline{\omega}$	0.4	0.75	0.9	0.95
Ratio of per worker hiring costs to quarterly wages (percent)	$\frac{\kappa\gamma_m^{-1}\theta^{\gamma}}{3w}$	39.8	16.2	6.4	3.2
Ratio of total hiring cost to output (percent)	$\frac{\kappa v}{y}$	2.67	1.11	0.44	0.22

We finally choose a baseline value of $\overline{\omega} = 0.9$, in the high side of the range of values considered in the literature. This requires setting $\kappa = 0.61$ and $b = 1.16$, where the latter also depends on the parameter that captures the complementarity.

5.2 Baseline results

Figure 3 illustrates the key dynamics at work in our model. It displays impulse responses to an increase in government spending corresponding to one percent of steady state output. All responses are expressed in percentage deviations from respective steady state values, with the exception of the unemployment rate that is expressed in absolute percentage points.

A rise in government spending produces a rise in the total surplus from the match. That the surplus is rising can be inferred from the behavior of the reservation wages, with the firm's reservation wage rising and the household's falling: hence the response of *both* reservation wages contributes to the widening of the surplus area. The firm's reservation wage rises because, despite the fall in the marginal product of labor, the expected discounted continuation value from the match increases. The household's reservation wage falls both because the current relative value of non-work activity ω_t falls and because the expected continuation value rises. The relatively larger fall in the household's reservation wage induces a fall in the bargained wage.

Figure 4 displays impulse responses of key selected variables to the same percentage increase in government spending as above. The responses of consumption and investment are expressed in percentage points of steady state output. The increase in government spending leads to a significant rise in market tightness and a fall in unemployment of slightly more than 0.2 percentage points at the peak, less than our SVAR estimates. Output increases by about 0.2 percent at the peak, much less than estimated from the SVARs. Consumption falls by about 0.9 percent, in contrast with our empirical evidence which shows consumption to increase. Investment falls by almost 0.4 percent at the peak, and the real wage falls initially by 0.3 percent relative to baseline.

Figure 5 reports both *output and unemployment multipliers* (calculated at different horizons) implied by our simulation. The output multiplier at horizon j is measured as the ratio between the cumulated impulse response of output and the cumulated response of government spending both at horizon j (expressed in units of steady state output). The unemployment multiplier is computed as the fall in unemployment at the peak expressed in percentage points. The figure illustrates how both multipliers vary with parameter $\overline{\omega}$. We let $\overline{\omega}$ vary between 0.4, which is the value advocated by Shimer (2005), and 0.95 which is about the value indicated in Hagedorn and Manowski (2008). We report two horizons for the output multiplier: impact and one-year. We see that the value of $\overline{\omega}$ has a critical effect on the size of both multipliers. For values of $\overline{\omega}$ close to 0.4 both the output and the unemployment multipliers are close to zero

A main result is that at all horizons the output multiplier is quite small, largely below 1. This finding is remarkable because it is obtained in the context of a model in which the implicit employment elasticity is high (as implied by the calibration of $\overline{\omega} = 0.9$). The main reason for the small size of the output multiplier relies in the behavior of investment, which falls over time in response to the increase in government spending. Conversely, the unemployment multiplier can get sufficiently close to our SVAR estimates if the value of $\overline{\omega}$ is sufficiently high.

The main implication of this section is that if we accept that a reasonable value for $\overline{\omega}$ should be in the high range (close to 0.9) then a neoclassical model augmented with search and matching frictions can generate unemployment multipliers that match our estimates fairly closely, whereas the output multipliers remain largely below our estimates.

6 Extensions

In this section we illustrate a series of modifications that have important implications for the size of the unemployment and output multipliers. Understanding how they work is important in order to highlight the channels of operation of fiscal policy in this model.

6.1 Non-separability

A recent literature has advocated non-separable preferences as a desirable feature of business cycle models of the labor market. Shimer (2009) argues that the marginal utility of consumption being dependent on work effort is consistent with microeconomic models of time allocation (Becker, 1969). Hall (2009) and Hall and Milgrom (2008) argue in favor of preferences that imply that the marginal utility of consumption rises at higher levels of hours worked.[20]

Figure 6 explores the implications of non-separability for the output and unemployment multipliers in our framework. The figure displays, for alternative values of σ, impulse responses of output and unemployment to a shock to government spending of the same size as in the previous exercises. The solid line corresponds to the baseline case of separable utility ($\sigma = 1$) analyzed earlier.

In the top panel we set $\overline{\omega} = 0.4$, whereas in the bottom panel we set $\overline{\omega} = 0.9$. Clearly, complementarity between consumption and employment *dampens* the size of both multipliers. In a number of cases, high values of σ even imply a change in the sign of the multiplier. The intuition for this result is that higher complementarity makes the marginal value of non-work activity less sensitive to the marginal utility of wealth. In fact, the (absolute) value of the elasticity of ω_t to λ_t is $1/\sigma$, which is decreasing in σ. Hence, for any given increase in the marginal utility of wealth (due to higher taxes), the higher is σ the smaller the fall in the marginal value of non-work activity, and hence the smaller the effect on the total surplus. In turn, this affects negatively equilibrium hiring.

This result is somehow the analog, within a search and matching model, of a similar result obtained in Monacelli and Perotti (2008), who show, within a neoclassical model with non-separable preferences, that the intensity of the wealth effect on labor supply is negatively related to the degree

[20] Hall (2009) refers to substantial evidence that consumption falls when hours of work fall, e.g., because of retirement or unemployment.

of complementarity between consumption and hours.

6.2 Unemployment benefits

So far we have assumed that the flow benefit from being unemployed only comes in the form of leisure gains. However, more generally, the flow value of unemployment can either include unemployment insurance collected from the government or a benefit from producing at home or in an informal market activity. These components are typically modelled in the literature as a fixed monetary benefit per unemployed worker. Since in our model the key channel through which increases in government spending stimulate hiring activity is via changes in the value of time, how we interpret the flow value of unemployment has important implications.

In this section we interpret the flow unemployment benefit not only as leisure value but also as unemployment insurance (which is equivalent to interpreting the benefit as home production). The introduction of unemployment benefits in the model modifies the household's budget constraint to include an additional term, as follows:

$$c_t + i_t + \mathbb{E}_t \left\{ \Lambda_{t,t+1} B_{t+1} \right\} \leq w_t n_t + b_u \left(1 - n_t\right) + r_{k,t} k_t + B_t + \pi_t - \tau_t, \tag{33}$$

where b_u is the value of unemployment benefits per unemployed worker. This will cause a change in the value of an employed household's member, $H_{n,t}$, in turn implying that the total surplus becomes

$$S_{n,t} = a_t - (\sigma b \lambda_t^{-1/\sigma} + b_u) + \beta \mathbb{E}_t \left\{ \left(\rho - \eta p_{t+1}\right) \Lambda_{t,t+1} S_{n,t+1} \right\}, \tag{34}$$

where the value of non-work activity is now the sum of two components: the marginal rate of substitution, $\sigma b \lambda_t^{-1/\sigma}$, and the unemployment insurance, b_u. With the purpose of understanding the effects of government spending shocks, the key aspect is that only the first component is affected by variations in the marginal utility of wealth. This implies that in the extreme case where we interpreted the flow value of unemployment as only unemployment insurance (or home production), the channel working via the marginal value of non-work activities would be absent. A rise in government spending would then unambiguously lead to a *decrease* in hiring, employment and output, as a consequence of the real interest rate and capital accumulation channels.

To explore the quantitative effects of allowing for unemployment insurance in the model, we first note that the expression for the average relative value of non-work to work activity is now given by

$$\overline{\omega}_b \equiv \frac{\sigma b \lambda^{-1/\sigma} + b_u}{a} = \overline{\omega} + \frac{b_u}{a}$$

We then modify the calibration as follows. We keep $\overline{\omega}_b = 0.9$ and we choose b_u so that the average replacement ratio, b_u/w, is 0.4, similarly to Shimer (2005). In fact, since the average marginal product a is close to the average wage w, this implies that b_u/a is close to b_u/w. It also implies that $(\sigma b \lambda^{-1/\sigma})/a$ is close to 0.5.

Figure 7 compares the response of output and unemployment to a government spending shock in the baseline case (where the flow unemployment benefit is interpreted only as the value of leisure) to the case where we also allow for unemployment insurance. As expected, the implied multipliers are lower in the case with unemployment insurance. The reason is simple: if $b_u > 0$, holding $\overline{\omega}_b$ constant implies setting a lower value of $\overline{\omega}$, and the effect on the surplus of variations in the marginal utility of wealth is dampened.

6.3 Wage rigidity

While the Nash rule is a natural way to split the surplus in search models, any wage within the bargaining set could in theory be an equilibrium outcome of the negotiation. This key observation has led a number of researchers, starting with Shimer (2005) and Hall (2005a), to investigate the role of rigid wages in search models.

As long as the (rigid) wage remains in the bargaining set, wage rigidity has no effect on the decision to form or continue a match once a worker and a firm have met. However, wage rigidity affects the *rate* at which firms post vacancies to attract new workers since it influences firms' expected gains from hiring a worker. Shimer (2005) and Hall (2005a) show that wage rigidity significantly amplifies the cyclical response of hiring activity to productivity shocks.

Figure 8 illustrates this point. A positive productivity shock generally affects the bargaining set in two ways: it tends to increase its size (as the match surplus increases) and tends to shift it toward higher wages (as both reservation wages, $\underline{w}_t$ and $\overline{w}_t$, generally increase). The rigid wage, then, moves toward the lower (upper) limit of the bargaining set in expansions (recessions), so that hiring incentives are high (low). Wage rigidity (illustrated by the vertical dashed line) amplifies the employment response to productivity shocks by making the firm share of the surplus procyclical, so that hiring is encouraged in booms and discouraged in recessions.

The effect of wage rigidity on hiring incentives in response to government spending shocks is in general, however, of the opposite sign. Consider a positive government spending shock that raises hiring and employment (that is, one for which the net effect of the three channels analyzed above is expansionary), as it is the case under our baseline calibration. The shock increases the size of the bargaining set (as it raises the surplus). As we have seen above, while the firm's reservation wage $\overline{w}_t$ rises in response to the shock, the worker's reservation wage $\underline{w}_t$ falls. Under our baseline calibration, the reduction in the workers's reservation wage is large enough relative to the increase in the firm's reservation wage so that the flexible Nash bargained wage falls. In equilibrium, both the firm's and the worker's *shares* of the surplus remain constant in equilibrium.

Suppose now, for the sake of illustration, that the real wage is strictly fixed (once again to the level indicated by the dashed vertical line in figure 8). In this case the firm's share of the surplus will *decrease* in response to positive government shocks, thereby discouraging hiring. Hence, in general, wage rigidity will *dampen* the effect of government spending shocks on hiring.

To make the argument more concrete, we extend the model to incorporate real wage rigidity. We do this through a simple wage adjustment rule.[21] We distinguish between a target wage, w_t^{nb}, which is determined by the Nash bargaining solution, and the actual wage, w_t, which is a weighted average of the target wage and last period actual wage. The rule is given by

$$w_t = (1 - \chi)w_t^{nb} + \chi w_{t-1},$$

where χ is a partial adjustment parameter that reflects the degree of wage rigidity. When $\chi = 0$, the actual wage corresponds to the Nash bargained wage and we recover the baseline case.

[21] See Gertler and Trigari (2009) for a model of staggered Nash wage bargaining.

Figure 9 displays impulse responses for output, unemployment, the worker's and the firm's share of the surplus under alternative values of the parameter χ. It shows that the firm's (worker) share of the surplus decreases (increases) in the aftermath of the shock, with the effect on the firm and worker shares being larger the higher is the degree of wage rigidity. We see that, as anticipated from our intuition above, a higher degree of real wage rigidity tends to dampen the size of both the output and the unemployment multipliers.

6.4 Debt financing and distortionary taxes

Thus far we have assumed that government spending is financed via lump-sum taxes levied on the household, and that the government budget constraint is balanced in every period. In this section we wish to explore the implications of distortionary taxation and debt financing.

The household's budget constraint becomes:

$$c_t + i_t + \mathbb{E}_t \{\Lambda_{t,t+1} B_{t+1}\} + B_{g,t+1} \leq w_t n_t (1 - \tau_t^n) + r_{k,t} k_t + (1 + r_t) B_{g,t} + \pi_t - \tau_t, \qquad (35)$$

where τ_t^n is the tax rate on labor income[22] and $B_{g,t}$ is one-period real government debt purchased in $t-1$ and paying off a net return of r_t.

The government budget constraint now reads:

$$B_{g,t+1} + \tau_{n,t} w_t n_t + \tau_t = g_t + (1 + r_t) B_{g,t}.$$

The government adjusts each fiscal instruments according to the following feedback rules:

$$\log(f_t) = (1 - \rho_f) \log(f) + \rho_f \log(f_{t-1}) + \phi_f \log\left(\frac{B_{g,t}}{B_g}\right) + \varepsilon_{f,t}, \qquad (36)$$

where $f_t = \tau_{n,t},\ g_t,\ \tau_t$ respectively, and f is the steady state value of f_t.

Distortionary taxation on workers' labor income affects firms' hiring decision in two ways. On the one hand, it reduces the total surplus from employment. The total surplus from the marginal match is reduced by the amount of the total tax paid, $\tau_{n,t} w_t$. On the other hand, it increases the

[22] We abstract here from capital income and consumption taxes.

share of the surplus accruing to the firm, that becomes $(1-\eta)/(1-\eta\tau_t^n)$. This happens because a unit rise in wages yields a cost to the firm of one unit but a benefit to the worker of one unit less the tax rate. So, the tax rate induces a joint loss to the firm and the worker that can be reduced by keeping wages low or, equivalently, by keeping the firm's share of the surplus high. To summarize these effects, we solve for the total surplus and combine with the hiring equation in presence of distortionary taxation and obtain

$$\kappa\gamma_m^{-1}\theta_t^\gamma = (1-\eta)\left(a_t - \frac{\omega_t}{1-\tau_{n,t}}\right) + \beta\mathbb{E}_t\left\{(\rho - \eta p_{t+1}\mathcal{T}_{t+1})\Lambda_{t,t+1}\kappa\gamma_m^{-1}\theta_{t+1}^\gamma\right\}, \tag{37}$$

where

$$\mathcal{T}_{t+1} \equiv \mathbb{E}_t\left\{\frac{\rho}{p_{t+1}}\left(1 - \frac{1-\tau_{n,t+1}}{1-\tau_{n,t}}\right) + \frac{1-\tau_{n,t+1}}{1-\tau_{n,t}}\right\} \tag{38}$$

is a composite term that depends on current and expected future distortionary tax rates. Note that in the absence of distortionary taxation ($\tau_t^n = 0$ for all t), equation (37) coincides with (26).

Distortionary taxation produces two effects on the hiring equation. For one, a rise in the current labor income tax rate tends to increase the tax-adjusted marginal value of non-work activity, $\omega_t/(1-\tau_t^n)$, lowering the surplus from the match, and therefore discouraging hiring. But in our context there is an additional (dynamic) effect captured by the term $\mathcal{T}_{t+1}$ and reflecting variations over time of the relative bargaining power. Notice that if distortionary tax rates were constant over time ($\tau_t^n = \tau^n$ for all t) we would have $\mathcal{T}_t = 1$ for all t, so that distortionary taxation would only affect hiring via changing the relative value of non-work to work activity.

Figure (10) compares the baseline model with lump-sum taxes (solid line) with the case in which government spending is financed with taxes on labor income and debt stabilization rules as in (36) are in place (dashed line). In this simulation exercise we assume $\phi_{\tau_n} = \phi_\tau = 0.02$, $\phi_g = -0.02$ and $\rho_{\tau_n} = \rho_\tau = 0.9^{1/3}$.[23]

The presence of distortionary taxes alters significantly the response of both output and unemployment to a rise in government spending: both the output and the unemployment multipliers are

[23] Leeper *et al.* (2009) estimate, within a DSGE model, feedback coefficients of fiscal rules for different instruments and find significant reaction to government debt. See also Galí and Perotti (2003), Bohn (1998) and Favero and Monacelli (2005), who report estimates for feedback coefficients to debt of roughly the size we calibrate here.

reduced relative to the case in which the higher spending is financed with lump sum taxes only. In addition, the dynamic response of both output and unemployment is altered: the increase in taxes necessary to stabilize government debt yields a quicker fall in output relative to the baseline case and even a rise in unemployment after about one and a half year.

7 Market power and countercyclical markups

Recent contributions (see, e.g., Christiano et al., 2009, Hall, 2009) have emphasized that so-called New Keynesian (NK) models, i.e., models characterized by the presence of imperfect competition and nominal price rigidity, can be more effective than the neoclassical growth model in generating large output multipliers from variations in government spending. The key lies in the behavior of markups. Under price stickiness, markups are counter-cyclical in light of any shock that boosts output and therefore the nominal marginal cost. This effect acts as a shifter of the standard marginal product of labor schedule, which reinforces the effect on employment stemming from the wealth effect on labor supply. It is therefore interesting to explore the implications of markup variations for the (un)employment multiplier in the context of our model.

To introduce monopolistic competition and nominal price rigidity we follow the modelling strategy adopted in Walsh (2005) and Trigari (2006, 2009). We add to the model a standard monopolistically competitive retail sector in which we locate rigidities in price setting. The firms' sector where search frictions are located is kept unchanged and is re-labeled as intermediate goods sector. Retailers buy goods from intermediate goods firms in competitive markets, differentiate them with a technology that transforms one unit of intermediate goods into one unit of retail goods, and re-sell them to the households.[24] Retailers adjust prices according to a conventional Calvo specification where $1-\phi$ denotes each period fixed probability of re-setting the price.[25]

We close the model by postulating a simple interest rate feed-back rule according to which the monetary authority adjusts the short-term nominal interest rate, r_t^n, in response to final consump-

[24] On top of retailers and intermediate good firms, final good firms combine individual retail goods into a final good using a Dixit-Stiglitz aggregator.

[25] In the interest of space, we do not describe the model with nominal rigidities. See Trigari (2006, 2009) for details.

tion goods inflation, π_t, and output growth:

$$(1 + r_t^n) = (1 + r)\pi_t^{\phi_\pi} \left(\frac{y_t}{y_{t-1}} \right)^{\phi_y} \tag{39}$$

with $\phi_\pi > 1$ and $\phi_y > 0$.

Note that the price of intermediate goods in terms of final goods corresponds to the real marginal cost of production faced by the retailers, that is, to the inverse price markup. This implies that the marginal product of labor in the intermediate goods sector expressed in terms of final goods is

$$a_{\mu,t} = \mu_t^{-1} a_t$$

where μ_t is the price markup. Hence movements in the markup affect the surplus equation via the marginal product of labor. In this context, the analog of the expression for the surplus is

$$S_{n,t} = a_{\mu,t} - \omega_t + \beta \mathbb{E}_t \left\{ (\rho - \eta p_{t+1}) \Lambda_{t,t+1} S_{n,t+1} \right\}$$

while the steady state relative value of non-work to work activity in terms of final goods reads $\overline{\omega}_\mu = \sigma b \lambda^{-1/\sigma} / a_\mu$. Due to price rigidity, counter-cyclical movements in the markup (both current and future) raise the effective marginal product of labor. In equilibrium, since hiring depends on the current and the expected future values of the marginal product of labor, this boosts hiring and employment.

We have shown above that, under flexible prices, complementarity between consumption and employment worsens the ability of the model to generate sizeable multipliers (both for output and employment). In this section we show that, if coupled with price stickiness, the effect of complementarity is *reversed*: if the degree of complementarity is sufficiently high, consumption can even rise and the output multiplier can be largely magnified.

In the baseline case we continue to assume $\overline{\omega}_\mu = 0.9$, we set a steady state markup of 16 percent, a four-quarter degree of price stickiness, and monetary policy parameters $\phi_\pi = 1.5$ and $\phi_y = 0.5/4$, in line with a standard Taylor rule (with the output coefficient normalized to monthly frequency). Figure 11 displays impulse responses of selected variables from the model with four-quarter price stickiness under alternative values of the complementarity parameter σ. Consider the case of separable preferences first ($\sigma = 1$). The output multiplier at the peak is about 0.6 whereas the unemployment multiplier rises further, to almost 0.8 (in absolute value). The key for the expansionary effect on output derives from the strong fall in the markup, which raises the current and expected future marginal product of labor, therefore boosting the current hiring rate. The output multiplier, however, still remains largely below 1.

Consider now the effect of increasing the degree of complementarity between consumption and labor. With $\sigma = 2$, in particular, the output multiplier, at the peak, rises above 1, whereas the unemployment multiplier is close to 2 (in absolute value). Notice also that the model even overshoots the value of the unemployment multiplier relative to the data; however, by combining the baseline NK model with some of the features discussed above, such as unemployment benefits, or debt financing under distortionary taxation, one could appropriately dampen that effect.

Importantly, for a value of $\sigma = 2$, now *consumption rises* in response to the government spending shock. It is important to recall that the econometric fiscal policy literature is divided on the effects of government spending shocks on private consumption: the SVAR strand tends to find (as we do and as in Perotti, 2007) that consumption rises significantly[26], whereas the narrative-approach strand (as in Ramey, 2009) tends to find that consumption either marginally falls or that it remains virtually unchanged. Despite the differences, however, nobody finds that government spending crowds out private consumption as much as our baseline model with flexible prices and search frictions implies. Hence it seems desirable to explore the role of modelling features (such as complementarity) that contribute at least to dampen the equilibrium response of consumption to government spending.

The intuition for the magnification effect that we obtained can be best understood in the limit case of prices being completely rigid, and the monetary policy rule being only responsive to inflation.[27] In that case, the real interest rate must be constant. In turn, this implies that the marginal utility of consumption must be constant through time:

[26] Other examples are Galí et al. (2007), Ravn et al. (2007).

[27] See Monacelli and Perotti (2009) for a related analysis in the context of a standard NK model with non-separable preferences.

$$U_c(c_t, n_t) = U_c(c_{t+1}, n_{t+1}) = \overline{U}_c$$

In equilibrium employment rises: this is a fortiori true in a model with price stickiness, for (as explained above) falling markups boost the marginal product of labor and in turn the hiring rate. But for the marginal utility of consumption to remain constant in light of a rise in employment, consumption must necessarily rise. This complementarity effect is then stronger the higher is σ. At higher levels of σ consumption will rise more for any given level of employment, with this requiring further decreases of the markup and, in equilibrium, higher labor demand. Hence the multiplier effect on consumption transfers naturally to employment and to output.

In our model with staggered prices and a more general monetary policy rule, the real interest rate is obviously not completely fixed. Yet, as we see from the picture, this intuition survives, as long as movements in the real interest rate are not too strong. In this respect, recall also that parameter σ does not only pin down the complementarity between consumption and hours, but also the inverse *elasticity of intertemporal substitution* in consumption.[28] Hence, as σ rises, even in the case of relative large movements in the real interest rate, these would have smaller effects on the current marginal utility of consumption.

8 Conclusions

This paper is a first-step exploration into the effects of variations of government purchases on the labor market and unemployment in particular. Our main message is that a baseline real business cycle model augmented with search and matching frictions has several problems in replicating the size of the output and unemployment multipliers that we find in the data. Our theoretical analysis suggests that a framework with New Keynesian features and complementarity in utility between consumption and labor holds promise in matching several facts of the transmission of government spending on the labor market. However, several channels have remained unexplored. We can think of at least three: first, endogenous job destruction; second, a labor market participation choice;

[28] See Trabandt and Uhlig (2009) and Monacelli and Perotti (2008).

third, a meaningful role for public employment expenditure. On the latter, Quadrini and Trigari (2007) and Gomes (2010) are interesting examples.

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Figure 1

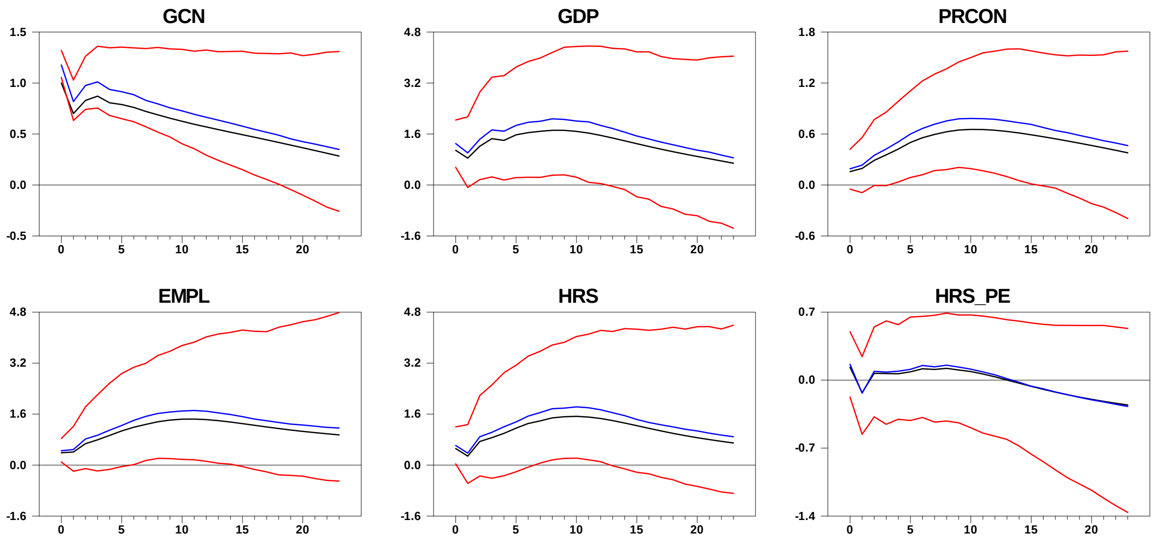

Figure 1: Estimated impulse responses from the VAR

Figure 2

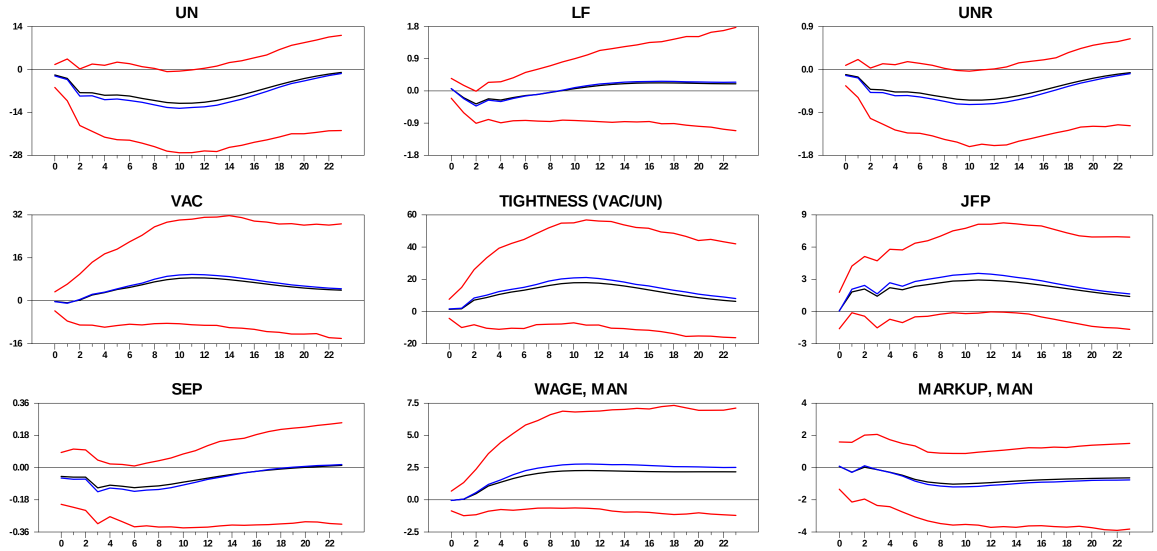

Figure 2: Estimated impulse responses from the VAR

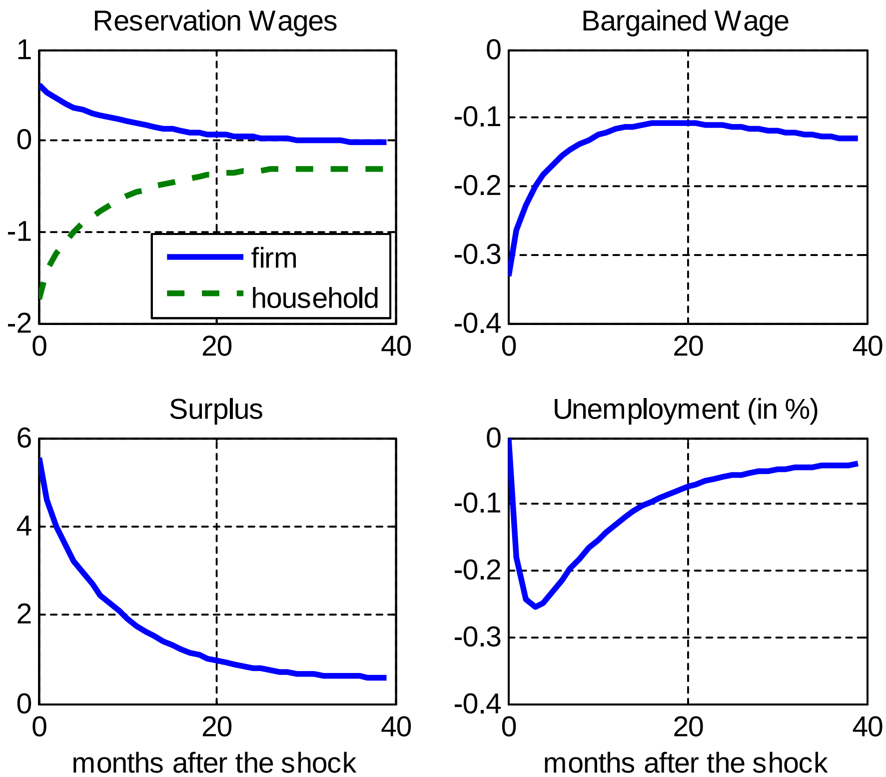

Figure 3: Responses to a rise of government spending equal to 1% of GDP.

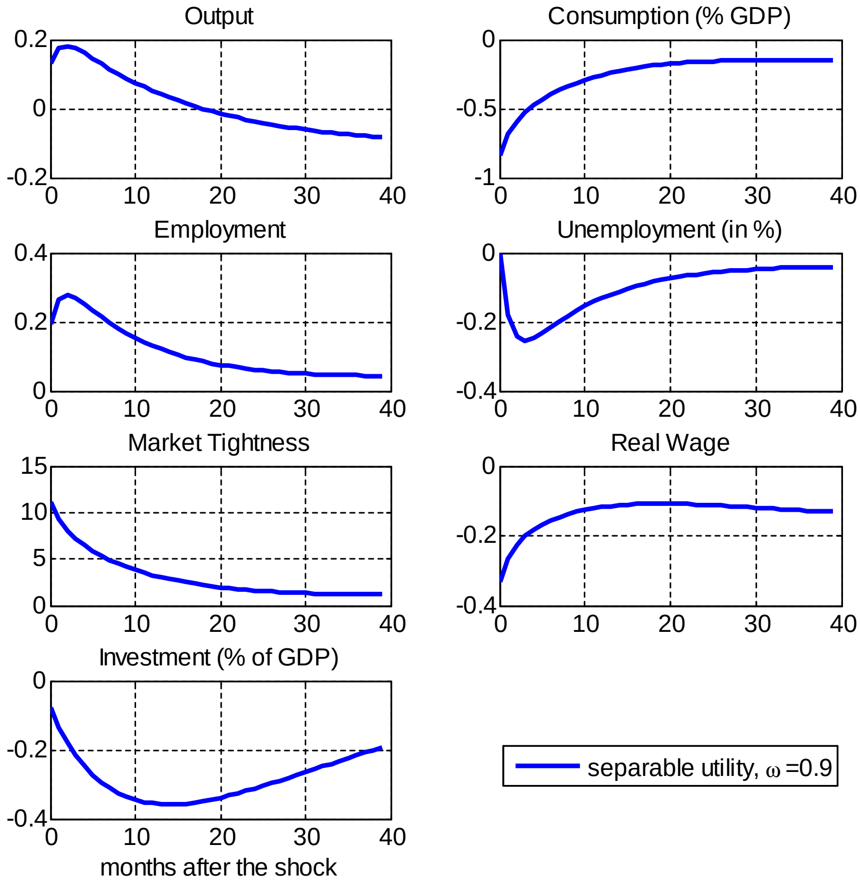

Figure 4: Responses to a rise of government spending equal to 1% of GDP.

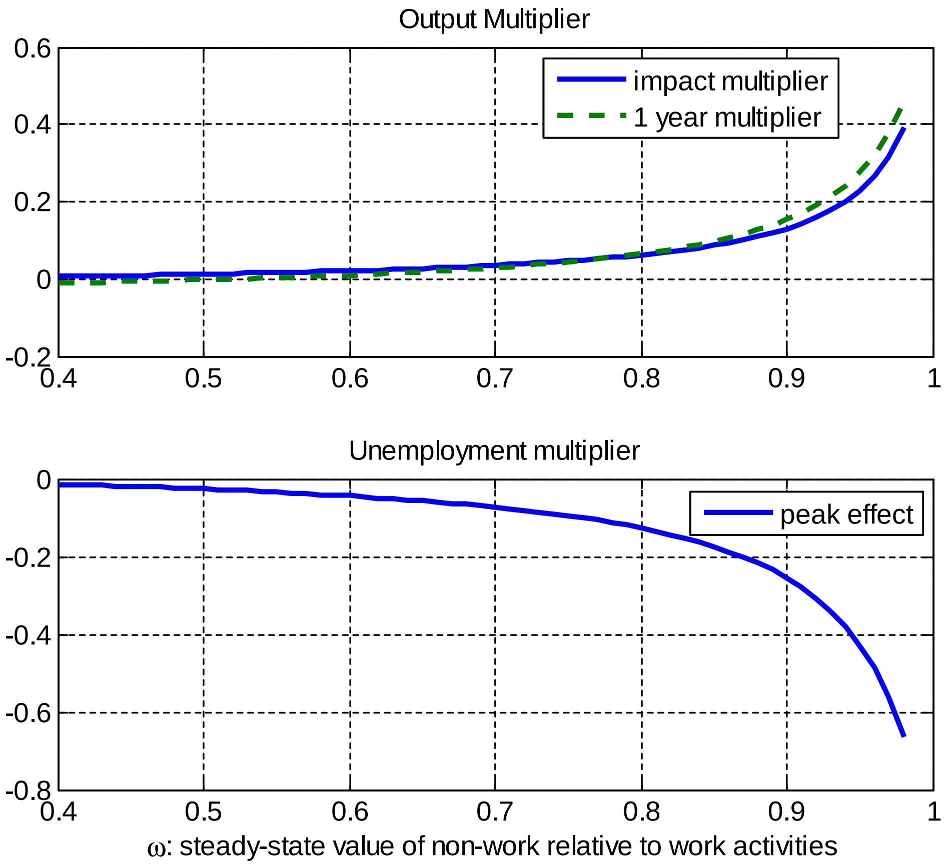

Figure 5: Output and unemployment government spending multipliers.

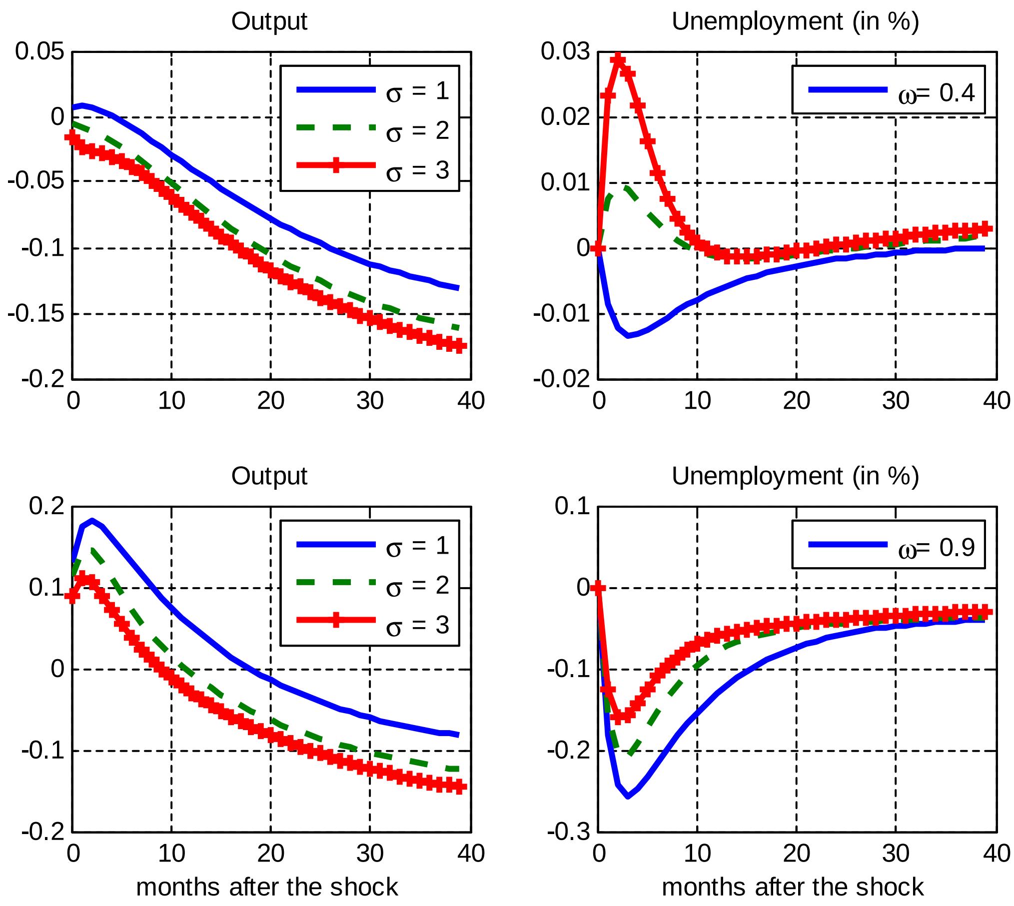

Figure 6: Effect of varying σ on the responses of output and unemployment: top panel $\overline{\varpi} = 0.4$, row panel $\overline{\varpi} = 0.9$.

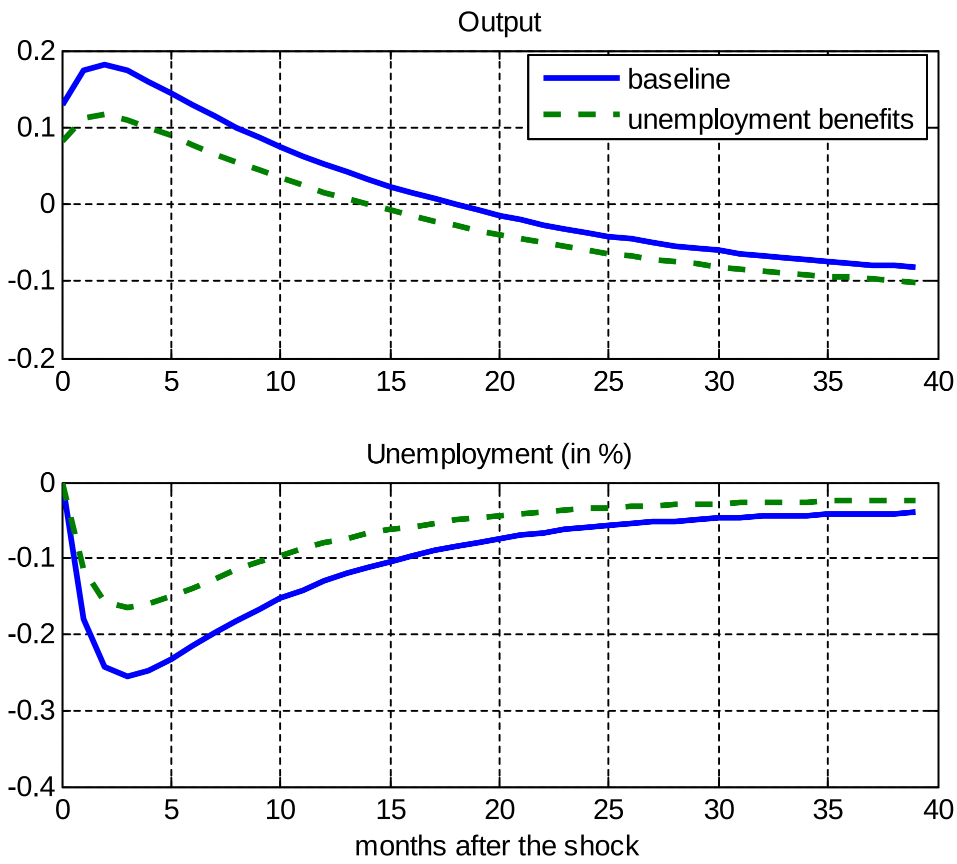

Figure 7: Effect of introducing unemployment benefits on the response of output and unemployment to a government spending shock.

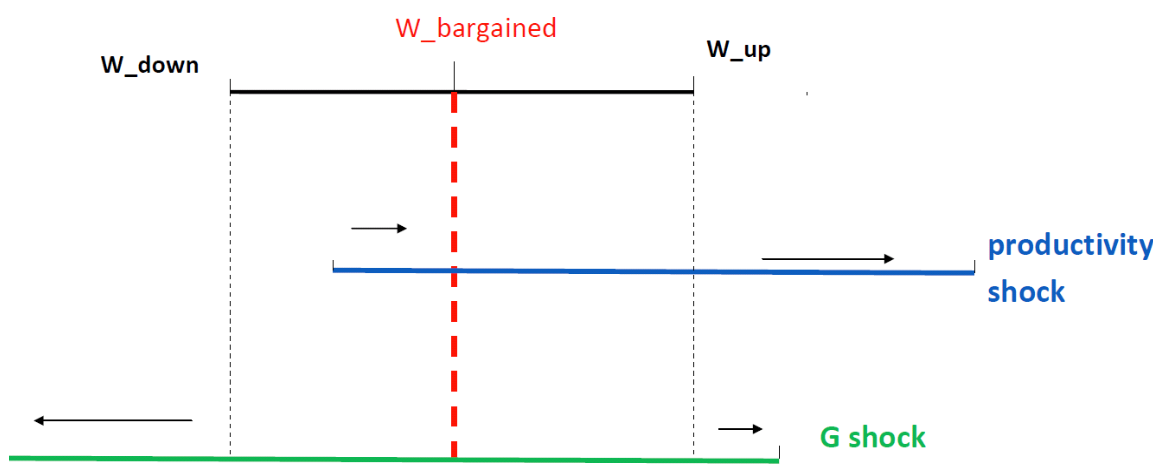

Figure 8: Real wage rigidity amplifies the effects of productivity shocks but dampens the effects of governments spending shocks.

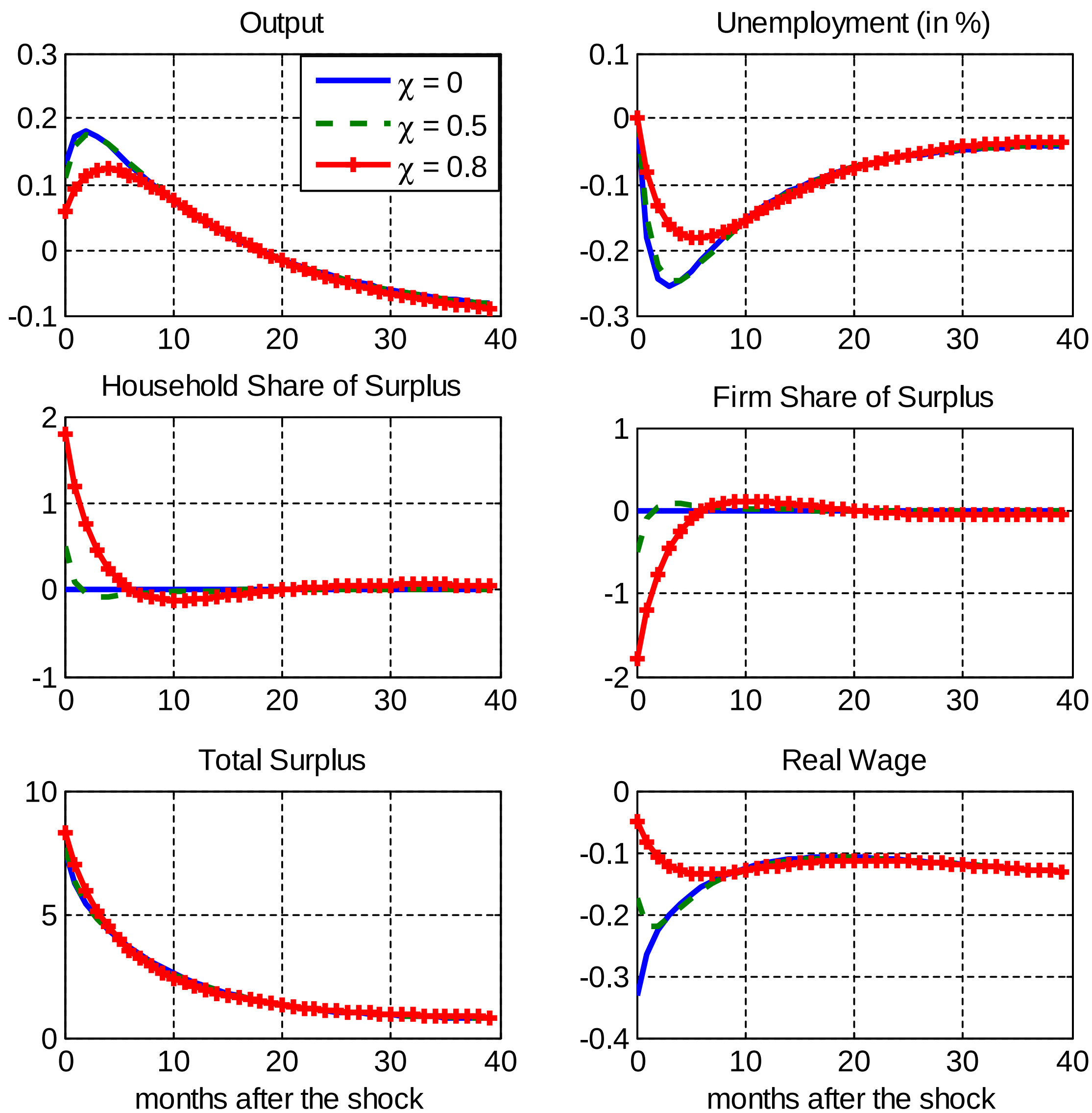

Figure 9: Effect of introducing real wage rigidity.

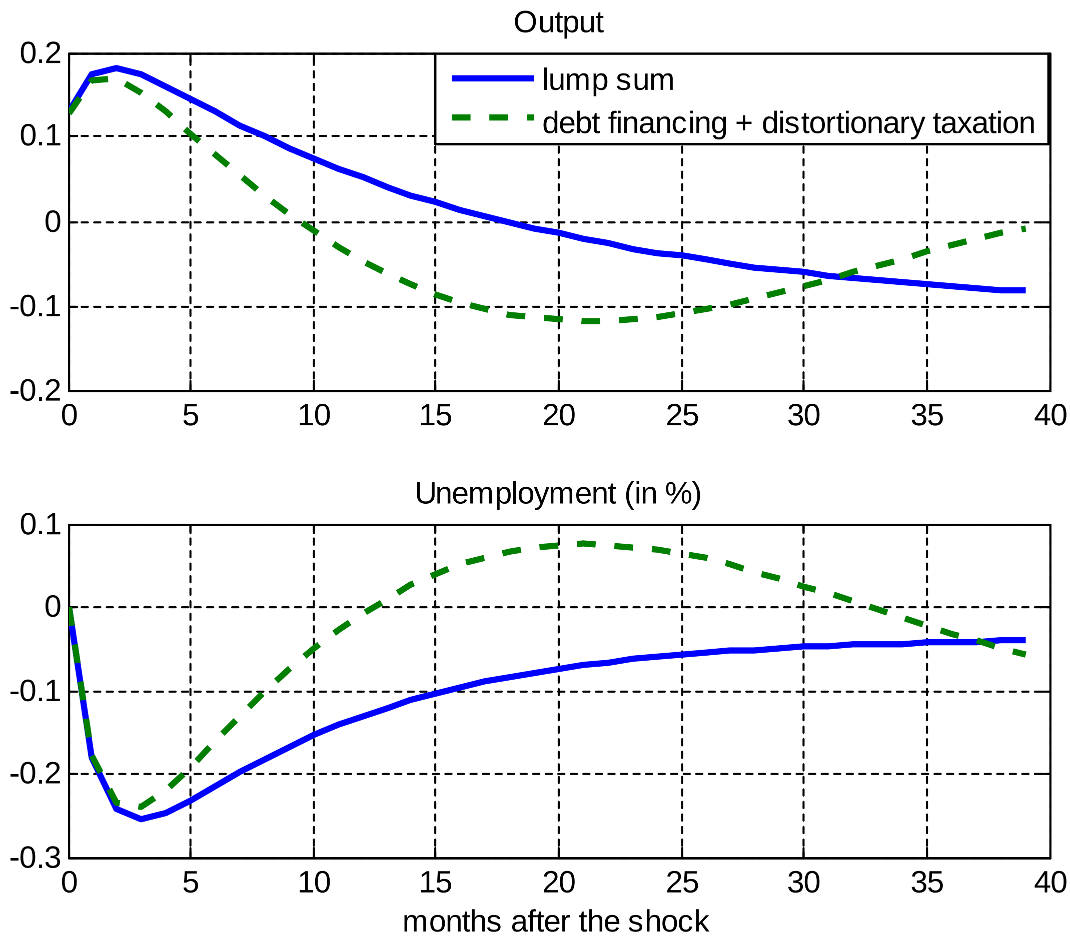

Figure 10: Effect of introducing distortionary taxation and government debt financing.

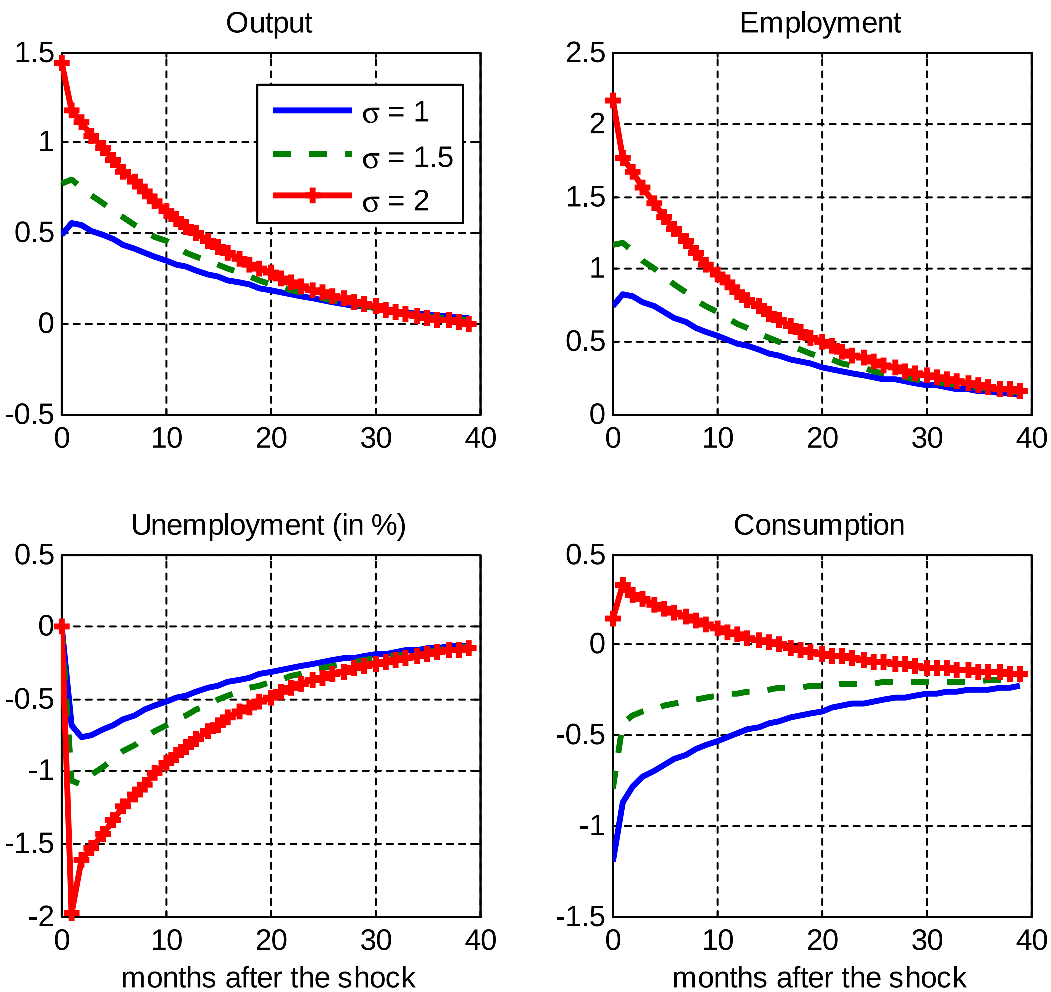

Figure 11: Impulse responses to a government spending shock under price stickiness and alternative degrees of complementarity.