Fiscal Shocks, Job Creation, and Countercyclical Labor Markups

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Abstract

Changes in government spending may serve as a coordination mechanism in at least some labor markets, helping to more easily bring together individuals looking for jobs with firms looking for workers. If government spending increases matching efficiency in this way, using Walrasian labor markets to study how innovations in government purchases affect the economy may miss an important transmission channel. Using preliminary empirical evidence on the covariance between government spending shocks and movements in matching efficiency, we construct a simple dynamic model with labor search frictions that captures this relationship. Our main result is that a positive government spending shock increases employment at both the extensive and intensive margins and leads to a countercyclical movement in the markup of price over the real wage. Our results, particularly the countercyclical response of the markup following a demand shock, bridges a gap in the existing literature studying the effects of fiscal policy shocks. The important link in the dynamic response of the model is a shift in the job creation schedule, which is the labor search model’s analog of the Walrasian labor demand schedule.

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1 Introduction

Changes in government spending may serve as a coordination mechanism in at least some labor markets, helping to more easily bring together individuals looking for jobs with firms looking for workers. For example, consider a government contract awarded to an employer in a particular industry, perhaps in a specific region of the country. The announcement of the contract may signal to job seekers that not only will that particular firm be looking to hire workers in the near future, but also that firms in close geographical or industrial proximity may expand employment due to spillovers from the initial demand shock (for example, though sub-contracting). This signal thus serves to reduce, at least temporarily, matching frictions between firms seeking workers and individuals seeking jobs. These effects may then spread out from region to region and industry to industry, ultimately affecting the aggregate economy.

If government spending increases matching efficiency in this way, using Walrasian labor markets to study how innovations in government purchases affect the economy may miss an important transmission channel. In this paper, we use preliminary empirical evidence on the covariance between government spending shocks and movements in matching efficiency to construct a simple dynamic model with labor search frictions that captures this relationship. Our main theoretical result is that a positive government spending shock increases employment at both the extensive and intensive margins and induces a countercyclical movement in the markup of price over the real wage even though prices are fully flexible.

The countercyclical markup our model generates bridges a gap between studies of the effects of government spending shocks conducted in flexible-price models versus those conducted in models with nominal rigidities. Much of the tension between these two classes of models can be traced back to adjustment in the labor market. Flexible-price models assume that adjustment occurs entirely through labor supply, while sticky-price models allow for the possibility of labor demand adjustment on the part of firms. Despite differences regarding the labor market response to an aggregate demand shock, there is one important element linking the two classes of models: both assume frictionless labor markets.

In this paper, we take the view that understanding the propagation of a fiscal shock requires a more realistic model of the labor market, one that moves away from the assumption of frictionless markets.1 Furthermore, once we allow for these frictions, it opens up the possibility that government spending shocks interact directly with adjustment in the labor market. This leads us to a significant departure from the existing fiscal policy literature. Our model extends the Mortensen and Pissarides (1994) model of labor market matching in a DSGE framework to allow for interaction between

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government spending and matching efficiency. We then study the effect of a government spending shock in a model in which labor market adjustment takes place at both the intensive and extensive margins.

The important link in the dynamic response of our model is a shift in the job creation schedule, which is the analog of the Walrasian labor demand schedule. When fiscal stimulus hits our model economy, it improves matching efficiency. As a result, firms find it less costly to invest in forming matches, inducing them to try to increase employment at the extensive margin by creating more vacancies. This outward shift in the job creation schedule increases labor market tightness, defined as the ratio of the number of vacancies to the number of unemployed individuals. Increased tightness improves workers’ wage bargaining strength, causing the real wage to rise. With the marginal product of a worker fixed, the higher real wage means the markup falls.

The remainder of the paper is structured as follow. Section 2 discusses in a little more detail how this paper fits in with the existing fiscal policy literature. Section 3 presents some preliminary empirical evidence linking shocks to government spending to shifts in matching efficiency in the labor market. In Section 4 we present our model, describe the equilibrium, and present our calibration. Our main findings are presented in Section 5, with a more detailed discussion of the key results in Section 6. Section 7 concludes.

2 The Response of the Labor Market to Fiscal Policy Shocks

There are two main classes of models that have been used to study the effects of government spending shocks on the aggregate economy. The standard neoclassical model predicts that an expansionary fiscal shock transmits through a negative wealth effect, as in Aiyagari, Christiano, and Eichenbaum (1990) and Baxter and King (1993). In the neoclassical model, government spending crowds out private consumption, increases household labor supply, and decreases the real wage. Empirical evidence in support of the wealth effect as the primary transmission channel is given by Ramey and Shapiro (1998), Burnside, Eichenbaum, and Fisher (2004) and Edelberg, Eichenbaum, and Fisher (1999).

This view, however, has not gone unchallenged. Rotemberg and Woodford (1992) criticize the wealth effect as the primary transmission mechanism because the perfectly competitive input and product markets in the neoclassical model mean that adjustment in the labor market occurs entirely through the household labor supply decision. Rotemberg and Woodford (1992) argue that imperfect competition is an important part of the story because it allows the potential for firms to adjust labor

Merz (1995) and Andolfatto (1996) were the first papers to embed labor market search in a DSGE framework. More recent examples include den Haan, Ramey, and Watson (2000), Walsh (2003), Trigari (2004), and Krause and Lubik (2005), and the literature in this field continues to grow rapidly.
demand through movements in the markup of price over marginal cost. With the markup possibly varying, the response to a fiscal shock can be very different than in the pure neoclassical model. In particular, if the labor demand response is large enough it results in a rising real wage, which serves to dampen the fall in consumption. If large enough, the rise in the real wage can even generate a positive consumption response to a positive government spending shock. This latter effect is generated in the models of, for example, Rotemberg and Woodford (1992), Devereux, Head, and Lampham (1996), and Gali, Lopez-Salido, and Valles (2006). Empirical evidence in support of this view is given by Rotemberg and Woodford (1992), Fatas and Mihov (2000), Blanchard and Perotti (2002), Mountford and Uhlig (2005) and Gali, Lopez-Salido, and Valles (2006).

The two competing views predict very different adjustments in the labor market following a government spending shock. Yet they both assume very simple labor markets. We thus think it useful to take more seriously labor market adjustments when studying the effects of government spending shocks.

The paper most closely related to ours in idea is Yuan and Li (2000), who also study government spending shocks in a DSGE model with labor market search. They find that employment at the extensive margin falls in response to expansionary fiscal policy and employment at the intensive margin (hours worked) rises. As we will make clear, our results differ from Yuan and Li (2000) due to the interaction between government spending and matching efficiency, one that we think is plausible and for which we provide some empirical support.\footnote{Exploring how matching efficiency is affected by macroeconomic conditions is a topic that has not received much attention. We think that it is plausible that such links may exist, not just between government spending shocks and matching efficiency but perhaps also between other aggregate shocks and matching efficiency. A previous version of Hagedorn and Manovskii (2006) also noted this idea that allowing for correlation between productivity shocks and matching efficiency may allow labor matching models to better match some business cycle facts.}

3 Effects of Government Spending on Matching Efficiency

In this section, we provide some preliminary empirical evidence on the link between government spending and matching efficiency. Our starting point is the usual Cobb-Douglas matching function found in the labor market search literature,

\[ m_t = \psi_t u_t^\xi u v_t^{1-\xi u}, \]

where \( m_t \) is the number of new employer-employee matches formed in period \( t \), \( u_t \) is the number of individuals unemployed and searching for a job, \( v_t \) is the number of unfilled vacancies, and \( \psi_t \) is a measure of matching efficiency. Note that we allow \( \psi \) to vary over time, a departure from much of the literature.
We wish to investigate whether there is evidence of a link between shocks to government spending and shocks to matching efficiency. To do so, we proceed in two steps. The first step is obtain a series for matching efficiency, \( \ln \psi_t \). Following Blanchard and Diamond (1989), we log-linearize the matching function and introduce a time trend. Also following their lead, we regress log-matches on log-lagged-unemployment and log-lagged-vacancies. The resulting equation that is estimated is

\[
\ln m_t = a + \ln \psi_t + bt + \xi_u \ln u_{t-1} + (1 - \xi_u) \ln v_{t-1},
\]

where \( t \) is the time trend. To estimate (2), we use quarterly data (1982:Q1 to 2004:Q4) on the job-finding probability, unemployment, and vacancies. The job-finding probability of a worker serves as a proxy for the number of matches, which is one way existing empirical studies of matching functions proxy for matches. Our estimate \( \xi_u = 0.25 \) is in line with the existing studies surveyed in Petrongolo and Pissarides (2001). The residual from this regression is our empirical measure of matching efficiency. Our procedure for obtaining this series is analogous to how TFP series are constructed using data on output and factors of production. The matching function is simply a technology.

With this empirical measure of matching efficiency in hand, we investigate whether there is an empirical link with government spending in two ways. First, we estimate a VAR(1) using our constructed log-matching efficiency series and the log-level of government spending. For robustness, we use five different measures of government spending: an index of total government expenditure, the ratio of government consumption expenditures to GDP, the ratio of government defense expenditures to GDP, real government consumption expenditures, and real government defense expenditures. The estimated system is

\[
\begin{pmatrix}
\ln \psi_t \\
\ln g_t
\end{pmatrix}
= \begin{pmatrix}
(1 - \rho_\psi) \ln \bar{\psi} \\
(1 - \rho_g) \ln \bar{g}
\end{pmatrix}
+ \begin{pmatrix}
\rho_\psi & \rho_{\psi g} \\
\rho_g & \rho_g
\end{pmatrix}
\begin{pmatrix}
\ln \psi_{t-1} \\
\ln g_{t-1}
\end{pmatrix}
+ \begin{pmatrix}
\epsilon_\psi^t \\
\epsilon_g^t
\end{pmatrix},
\]

where \( (\epsilon_\psi^t, \epsilon_g^t)' \sim N(0, \Sigma) \). Our idea that government spending shocks influence matching efficiency amounts to the hypothesis that \( \sigma_{\psi g} \neq 0 \), meaning the innovations in the two processes are correlated. Table 1 presents results. In almost all cases, the two innovation series have a positive covariance and the correlation between the two is significant at the five percent level. Furthermore, this finding is robust to the inclusion of a second lag in the VAR as well as the inclusion of lagged output growth to address the possibility that government spending by itself simply proxies for business cycle fluctuations.

Alternatively, we run some simple regressions of matching efficiency on lagged growth in government spending. If the data are consistent with our hypothesized transmission channel, we would

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4 All data were obtained from Robert Shimer’s webpage: http://home.uchicago.edu/~shimer/.

5 All government spending data were taken from the NIPA tables on the BEA website: http://www.bea.gov.
expect growth in government spending to enter with a significant positive coefficient. Results are presented in Table 2. Overall, the results are supportive of our hypothesized link.

We interpret the empirical evidence in Tables 1 and 2 as suggestive that there is a link between shifts in government spending and shifts in matching efficiency. There are likely a host of other ways to test this hypothesis, including testing the idea in less of a reduced-form way, such as, for example, testing whether search intensity or job advertising is affected by government spending shifts.\textsuperscript{6} We leave a more detailed empirical analysis to future research and instead turn to a theoretical framework that captures in a simple way our idea in order to study the effects of government spending shocks.

4 Model

The model we construct to study the effects of government spending shocks is essentially the Pissarides (2000) textbook search model. Our presentation of the model draws on Krause and Lubik (2005), although our model has flexible prices. The departures from the basic model are that we allow for interaction between government purchase shocks and movements in matching, as documented in Section 3, as well as variations in hours worked.

4.1 Households

Let $u(c_t)$ be the household’s instantaneous subutility function over consumption and $v(h_t)$ the subutility function over hours worked.\textsuperscript{7} These functions satisfy $u'(c_t) > 0$, $u''(c_t) < 0$, $v'(h_t) < 0$, and $v''(h_t) > 0$. The representative household chooses sequences of consumption of real bond holdings and a continuum of differentiated goods, $\{c_{it}, b_t\}$, to maximize

$$\sum_{t=0}^{\infty} \beta^t [u(c_t) + v(h_t) + (1 - \chi_t)A]$$

subject to the flow budget constraint

$$\int_0^1 p_{it}c_{it}di + b_t + t_t = y_t' + R_{t-1}b_{t-1} + d_t,$$

where $p_{it}$ is the relative price of good $i$, $b_t$ denotes holdings at the end of period $t$ of a risk-free privately-issued real bond, each unit of which pays a gross real return $R_t$ at the beginning of $t+1$.

\textsuperscript{6}Pissarides (2000, Chapter 5) discusses how variable search intensity on the part of individuals and variable advertising on the part of firms can be interpreted as input-augmenting technical change, which would show up in a reduced-form way as a shift in the matching efficiency parameter.

\textsuperscript{7}A household is composed of a continuum of individuals, each of whom is either employed or unemployed during a given unit of time. We follow the convention in the literature by assuming that members of a household enjoy perfect insurance against unemployment.
Real labor income is denoted by $y_l$, $t_t$ denotes lump-sum taxes paid to the government, and $d_t$ denotes profit income received from firms, which the consumer takes as given. The household does not choose hours of work $h_t$. Instead, hours are determined through bargaining between workers and firms, as described in Section 4.4. The parameter $A$ in the instantaneous utility function is the utility value of home production if unemployed, and the indicator variable $\chi_t = 1$ if employed in period $t$ and zero otherwise. Any individual that is not employed is searching for a job — thus, there are no individuals outside the labor force.

The consumption index $c_t$ is a CES function of the differentiated products,

$$c_t = \left[ \int_0^1 c_{it}^{\frac{1-\varepsilon}{\varepsilon}} di \right]^{\frac{\varepsilon}{1-\varepsilon}},$$

with $\varepsilon > 0$ is the elasticity of substitution between different goods. The household’s first-order conditions yield demand functions for each good $i$

$$c_{it} = p_{it}^{\frac{-\varepsilon}{\varepsilon'}} c_t$$

and the consumption Euler equation

$$u'(c_t) = \beta R_t E_t u'(c_{t+1}).$$

4.2 Government

Government purchases are exogenous and are financed by contemporaneous lump-sum taxes. The flow government budget constraint is thus

$$t_t = g_t,$$

where $g_t$ denotes real government expenditures and $t_t$ the lump-sum tax. Government purchases follow an AR(1) in logs,

$$\ln g_{t+1} = (1 - \rho_g) \ln \bar{g} + \rho_g \ln g_t + \epsilon^g_{t+1}$$

where $\bar{g}$ denotes the mean level of government spending and $\rho_g$ the persistence of deviations. The innovation $\epsilon^g_t$ has mean zero, variance $\sigma^2_g$, and is a drawn from a joint distribution with the innovation in matching efficiency, as discussed in Section 4.5.

4.3 Firms

There is a continuum of firms, indexed by $i$, that produce and sell differentiated goods in monopolistically competitive product markets. Prices of all goods are flexible. Our assumption of imperfect competition in product markets is without loss of generality. We make the assumption just to bring
the interpretation of our results closer to the class of models stressed by Rotemberg and Woodford (1992) as being important for understanding the effects of demand shocks.

Each firm $i$ must engage in costly search for a worker to fill each of its job openings. In each job $j$ at firm $i$ that will produce output, the worker and firm bargain simultaneously over the hours $h_{ijt}$ that will be worked in that job and the hourly wage $w_{ijt}$ paid in that position. Output of job $j$ at firm $i$ is given by $q_{ijt} = z_t g(h_{ijt})$, where $g(h)$ may exhibit diminishing marginal product. Any two jobs $j$ and $k$ at firm $i$ are identical, so from here on we suppress the second subscript and denote by $h_{it}$ hours worked in any job at firm $i$, by $w_{it}$ the wage in any job at firm $i$, and so on. Total output at firm $i$ thus depends on the production technology and the measure of matches $n_{it}$ that produce,

$$q_{it} = n_{it} z_t g(h_{it}). \quad (11)$$

The total wages paid by firm $i$ in any given job are $w_{it} h_{it}$. The total wage bill of firm $i$ is the sum of wages paid at all of its positions,

$$W_{it} = n_{it} w_{it} h_{it}. \quad (12)$$

Firm $i$’s optimization problem is thus to choose its relative price $p_{it}$ (recall that we allow for monopolistic competition in output markets), employment $n_{it}$, and vacancies $v_{it}$ to maximize

$$\Pi_{it} = \sum_{t=0}^{\infty} \beta^t \phi_{t+1} \left[ p_{it} q_{it} - W(n_{it}) - \gamma v_{it} \right] \quad (13)$$

subject to the demand function it faces

$$q_{it} = p_{it}^{-\frac{\varepsilon}{1-\varepsilon}} q_t = n_{it} z_t g(h_{it}) \quad (14)$$

and the law of motion for employment

$$n_{it+1} = (1 - \rho^x)(n_{it} + v_{it} q(\theta_t)), \quad (15)$$

where $q(\theta_t)$ is the probability, taken as given by the firm, that a vacancy is filled by a worker. Firms incur the cost $\gamma$ for each vacancy created, and job separation occurs with exogenous fixed probability $\rho^x$.

Associate the multipliers $mr_{it}$ and $\mu_{it}$ to the production and employment constraints, respectively. The first-order conditions with respect to $n_{it}$, $v_{it}$, and $p_{it}$ are, respectively,

$$\mu_t = mr_t z_t g(h_t) - \frac{\partial W_t}{\partial n_t} + \beta E_t \left[ \left( \frac{\phi_{t+1}}{\phi_t} \right) (1 - \rho^x) \mu_{t+1} \right], \quad (16)$$

$$\frac{\gamma}{q(\theta_t)} = \beta E_t \left[ \left( \frac{\phi_{t+1}}{\phi_t} \right) (1 - \rho^x) \mu_{t+1} \right], \quad (17)$$

$$mr_t = \frac{\varepsilon - 1}{\varepsilon}. \quad (18)$$

8
We consider only symmetric equilibria, so the $i$ subscripts are dropped after taking first-order conditions. Condition (18) is the usual condition that with flexible prices and monopoly power, marginal revenue is constant and inversely related to the price elasticity of demand. As we discuss below, with labor market frictions, this term is just one component of effective marginal revenue.

Combining the optimality conditions (16) and (17) yields the job-creation condition,

$$\gamma q(\theta_t) = \beta E_t \left[ \left( \frac{\phi_{t+1}}{\phi_t} \right) (1 - \rho^2) \left( mr_{t+1} z_{t+1} g(h_{t+1}) - \frac{\partial W_{t+1}}{\partial n_{t+1}} + \frac{\gamma}{q(\theta_{t+1})} \right) \right],$$

which states that at the optimal choice, the vacancy-creation cost incurred by the firm is equated to the discounted expected value of profits from the match. This condition is a free-entry condition in the creation of vacancies. Viewed in $w - \theta$ space, the job-creation schedule is the labor-search model’s analog of the Walrasian labor demand schedule: for a fixed level of unemployment, the higher is the real wage, the fewer vacancies firms optimally create because the present-value of a match is smaller (that is, the term $\partial W_t/\partial n_t$ rises). Fewer vacancies for a fixed level of unemployment means a more slack labor market (i.e., $\theta$ decreases), hence (16) defines a downward-sloping locus in $w - \theta$ space.\(^8\)

Finally, note that the optimality condition on employment can be re-written as

$$mr_t - \frac{\mu_t - \gamma/q(\theta_t)}{z_h g(h_t)} = \frac{\partial W_t/\partial n_t}{z_h g(h_t)},$$

which shows that real marginal cost, given by the term on the right-hand-side of (20), equals the difference between the notion of real marginal revenue in a model without labor market frictions and a term that measures the value to a firm of a match. The first component on the left-hand-side of (20) corresponds to the conventional notion of marginal revenue because it is simply the multiplier on constraint (14). The second term on the left-hand-side arises from search frictions and measures the value to a firm of an existing worker. Absent search frictions, $\mu_t = 0$ and $\gamma = 0$, in which case the typical notion of marginal revenue equals marginal cost. Note that our measure of real marginal cost as the ratio of the compensation for one additional unit of labor to the marginal product of labor is marginal in the extensive sense. When a firm hires the marginal worker, it determines how many hours he should work as well as what hourly wage to pay him. The marginal worker’s output is $z g(h)$. The total wage bill for the marginal worker as a fraction of his output is what we refer to as the marginal labor cost of that worker. Labor market frictions drive a wedge between marginal labor cost and the usual notion of marginal revenue. We find the decomposition in (20), which was first brought to our attention by Krause and Lubik (2005, p. 11), useful in understanding the results we present in Section 5.

\(^8\)See Pissarides (2000, chapter 1) for more details.
4.4 Nash Bargaining

We assume that hours worked and the wage paid in any given job are simultaneously determined in a Nash bargain between the matched worker and firm.\(^9\) The choice of hours maximizes the joint surplus of the match, while the bargained wage divides the surplus between the worker and the firm. The resulting choice of hours that maximizes the joint surplus from the match satisfies a standard labor efficiency condition,

\[
Mr_t z_t g'(h_t) = \frac{-v'(h_t)}{u'(c_t)},
\]

which states the firm’s marginal revenue product equals the household’s marginal rate of substitution between consumption and leisure. The choice of hours is thus privately efficient because it maximizes the total surplus inside a match.\(^10\)

Bargaining over the wage yields

\[
w_t h_t = \eta (mr_t z_t g'(h_t) + \gamma \theta_t) + (1 - \eta) \left( \frac{A}{u'(c_t)} - \frac{v(h_t)}{u'(c_t)} \right),
\]

where \(\eta\) is the share of the match surplus that goes to the worker and \(1 - \eta\) the share that goes to the firm, and \(h_t\) is determined by (21). For convenience, we omit the details of the solution of the wage bargaining problem because it is well-known in the literature.\(^11\) We only point out that because we assume a disutility of labor, the household’s MRS between consumption and leisure (or, more precisely, a term resembling this MRS, because the consumer does not choose hours directly) appears in the bargaining solution.\(^12\)

4.5 Matching Technology

In period \(t\), the number of searching individuals \(u_t\) and the number of posted vacancies \(v_t\) yield \(\psi_t m(u_t, v_t)\) new worker-job matches. A match formed in period \(t\) will produce in period \(t + 1\) if it survives exogenous separation at the beginning of \(t + 1\). As in Section 3, matching efficiency \(\psi_t\) follows the process

\[
\ln \psi_{t+1} = (1 - \rho_\psi) \ln \bar{\psi} + \rho_\psi \ln \psi_t + \epsilon^\psi_{t+1}.
\]

The innovation \(\epsilon^\psi_t\) has mean zero, variance \(\sigma^2_\psi\), and has positive covariance with the shock \(\epsilon^g_t\) in (10).

\(^9\)Despite Shimer’s (2005) recent critique of the use of Nash bargaining in labor-search models and Hall’s (2005a, 2005b) recent proposals of tractable alternative models of wage determination, we proceed with Nash bargaining because the convention still stands in the literature.

\(^10\)See Pissarides (2000, p. 175-179) for more details on bargaining over hours.

\(^11\)A derivation can be found in the very closely-related model in Arseneau and Chugh (2006), which studies optimal taxation.

\(^12\)Note that it is \(v(h)\), not \(v'(h)\), that appears in the last term in (22), so formally the last term is not the MRS, but it is similar in spirit.
4.6 Equilibrium

The conditions describing a symmetric equilibrium of the model are: the household optimality conditions (7) and (8); the firm optimality conditions (16), (17), and (18); the matching technology (1); the law of motion for employment (15); the Nash solution for hours and the wage given by (21) and (22); exogenous processes for technology, government spending, and the matching shifter; and the resource constraint

\[ c_t + g_t + \gamma v_t = n_t z_t g(h_t). \]  

(24)

Note that total costs of posting vacancies \( \gamma v_t \) are a resource cost for the economy. The unknown processes are \{c_t, n_t, u_t, h_t, w_t, \theta_t, mr_t, \mu_t, R_t, g_t, z_t, \psi_t\}.

4.7 Model Parameterization

We assume that instantaneous utility over consumption and hours worked takes the form

\[ u(c_t, h_t) = \frac{c_t^{1-\sigma} - 1}{1 - \sigma} - \frac{\nu h_t^{1+\nu}}{1 + \nu}. \]

(25)

We set the curvature parameter with respect to consumption to \( \sigma = 2 \), consistent with many macro models, and \( \nu = 10 \), which yields an intertemporal labor supply elasticity along the intensive margin of 1/10. This value for \( \nu \) is more in line with micro-estimates of labor supply elasticity than the typically lower values for \( \nu \) used in macro models without an extensive margin. In macro models without an explicit extensive margin, lower values for \( \nu \) (and thus higher values for the intertemporal elasticity of labor supply) are a stand-in for the unmodelled variations in the extensive margin. Because we have both an extensive and an intensive margin, we follow micro evidence in choosing \( \nu \). With \( \nu \) thus chosen, we calibrate \( \nu \) so that the steady-state number of hours worked in a match is \( h = 0.33 \). We calibrate a quarterly model and accordingly set the subjective discount factor \( \beta = 0.99 \), yielding an annual real interest rate of about four percent.

The elasticity of demand for differentiated consumption goods is \( \varepsilon = 11 \), implying a steady-state gross markup of 1.1 and steady-state real marginal revenue of \( mr = 1/1.1 \). The production function is assumed to be

\[ g(h_t) = h_t^\alpha, \]

(26)

and for our baseline results we set \( \alpha = 0.7 \). Thus, \( g'(h) > 0 \) and \( g''(h) \leq 0 \).

As in our empirical work, we use a Cobb-Douglas matching function,

\[ m(u_t, v_t) = \psi_t u_t^{\xi_u} v_t^{1-\xi_u}, \]

(27)

with the elasticity of matches with respect to the number of searchers set to \( \xi_u = 0.40 \), following Blanchard et al (1989), and \( \psi_t \) the measure of matching efficiency. In steady-state, the measure of
searchers is \( u = 0.154 \), so that \( N = 1 - u = 0.846 \) is the measure of the labor force that produces. Note that production occurs after the realization of separations. Following the convention in the literature, we suppose that the unemployment rate is computed before the realization of separations. The probability of separation is set to \( \rho^x = 0.10 \), so that \( N/(1 - \rho^x) = 0.94 \) is the employment rate, implying a 6 percent steady-state unemployment rate. In order to match a steady-state matching probability \( q(\theta) \) of 0.70 for a vacancy, we set the steady-state matching efficiency parameter to \( \bar{\psi} = 0.66 \). This in turn implies steady-state vacancies of \( v = 0.1352 \), labor-market tightness \( \theta \equiv v/u = 0.879 \), and job-finding rate for workers \( \theta q(\theta) = 0.60 \).

The three exogenous processes

\[
\ln g_{t+1} = (1 - \rho_g) \ln \bar{g} + \rho_g \ln g_t + \epsilon^g_{t+1}, \tag{28}
\]

\[
\ln \psi_{t+1} = (1 - \rho_\psi) \ln \bar{\psi} + \rho_\psi \ln \psi_t + \epsilon^\psi_{t+1}, \tag{29}
\]

and

\[
\ln z_{t+1} = \rho_z \ln z_t + \epsilon^z_{t+1}, \tag{30}
\]

have innovations with mean zero and standard errors \( \sigma_g = 0.01 \), \( \sigma_\psi = 0.001 \), and \( \sigma_z = 0.007 \), respectively. The standard error of the shock to log government purchases is near the one we find in Section 3 and in line with that used in other studies. The persistence parameter we choose, \( \rho_g = 0.88 \), is also in the neighborhood of our estimate, and in line with that used in the literature. Mean government purchases \( \bar{g} \) are set so that they constitute 20 percent of total output in steady-state. The standard error of the shock to log technology is a commonly-used value in the RBC literature, and we set \( \rho_z = 0.95 \) also following the RBC literature. We assume a standard error of the log matching shifter smaller than in our empirical results in Section 3, although this is not critical for our results because our focus is on shocks to government purchases.

To capture the effect of government purchase shocks on labor matching documented in Section 3, we set the covariance between \( \epsilon^g \) and \( \epsilon^\psi \) to \( 2.5 \times 10^{-5} \), in line with our finding. In order to minimize the impact of comovements between \( g_t \) and \( \psi_t \), we set \( \rho_\psi = 0 \) despite our finding of considerable persistence in \( \ln \psi_t \). By assuming a purely transitory spillover of government purchase shocks to movements in matching efficiency, our results provide a lower bound for the persistence of government spending shocks transmitted through effects on labor matching.

Finally, the share of the match surplus going to the worker, which is the parameter \( \eta \) in the Nash bargain, is assumed to be \( \eta = 0.5 \). The worker and firm thus share the surplus equally, a common assumption in this class of models.
5 Quantitative Results

To study the dynamics of our model, we linearize, in levels, the equilibrium conditions of our model around the deterministic steady-state. After numerically computing the deterministic steady-state, we solve for linear decision rules using our own implementation of the algorithm described by Schmitt-Grohe and Uribe (2004).

5.1 Extensive and Intensive Margins

Figure 1 presents a 16-quarter impulse response in our benchmark model of several macro aggregates to a one-time, one-percent persistent positive shock to government spending that occurs in period 5. Because government spending and the matching shifter $\psi_t$ have positive covariance, the innovation in government spending induces a rise in $\psi_t$, as the top right panel shows. This rise in $\psi_t$ dies out after one period, however, because there is zero persistence in movements in mismatch.

Total output rises by about 0.1 percent, as the middle left panel shows, and the number of individuals working rises by a little less than 0.1 percent, as the bottom left panel shows. Employment at the extensive margin rises because of the temporary improvement in the matching technology. The rise in employment at the extensive margin, however, does not occur until period 6, one period after the shock hits, because it takes one period for new job matches to form. Because new jobs are created with a lag, in the period of the shock hours worked rise sharply, about 0.5 percent, as households try to dampen the fall in consumption due to the negative wealth effect that higher taxes (recall we assume all government spending is financed with contemporaneous lump-sum taxes) induce. This channel is similar to that of a neoclassical model — see, for example, Baxter and King (1993) — but operates through the bargaining process rather than being mediated through adjustments in the market wage. Specifically, examining condition (21), which determines the number of hours worked, a rise in the marginal utility of consumption due to the wealth effect induces a rise in $h$ because $mr$ and $z$ are unaffected by the government spending shock and because $v''(h) > 0$ and $g''(h) \leq 0$.

One period after the shock, however, after the extensive margin has adjusted, the rise in hours worked per match does not need to be as large because the rise in the number of workers supports consumption. Because of the lack of persistence in $\psi_t$, the rise in $n_t$ dies out relatively quickly — but not instantaneously because it takes several periods for the newly-formed matches to break up — which then causes a subsequent further small increase at the intensive margin. The nonmonotonic response of labor at the intensive margin gives rise to the nonmonotonic response of consumption, shown by the similar (but opposite in sign) response profiles of the two variables in Figure 1.

Figure 2 probes deeper into the response of other labor market measures. The top left panel shows the response of the bargained real wage, which rises and then slowly dies out. With hours
Figure 1: Response of macro aggregates to one-percent positive government spending shock, which occurs in period 5. All variables reported as deviation from steady-state.
rising, as shown in Figure 1, intensive adjustment puts downward pressure on the wage. This can be seen in the job-creation condition: all else equal, (19) shows that a rise in hours leads to a fall in the wage. This effect is the neoclassical labor-supply effect on the wage. However, in our model adjustment also occurs at the extensive margin: the number of workers in jobs is rising. The top left panel of Figure 2 shows that the upward pressure on the wage accompanying adjustment at the extensive margin dominates the downward pressure on the wage stemming from the RBC-type effect on labor supply.

The top right panel shows that labor market tightness follows a similar time path as the wage. As we make clear in Section 5.2, the simultaneous increases in \( w \) and \( \theta \) shows that job creation, which should be thought of as labor demand in our model, increases in response to the positive government spending shock. The middle left panel of Figure 2 shows that firms temporarily post more vacancies in response to the temporary improvement in matching efficiency, but this effect dies out after one period with \( \rho \psi = 0 \). With unemployment also falling (shown in the middle right panel) as additional matches are formed, the labor market tightens, as shown in the top right panel. Taken together, these results all show that labor demand rises. In Section 5.2, we shut down the intensive margin to reveal more clearly the effect on labor demand in our model.

The bottom two panels of Figure 2 reveal a central feature of our results. Total marginal revenue, composed of the constant term in (18) as well the term measuring the value of an employee as shown in (20), fluctuates over time. Marginal labor cost thus varies over time as well. The lower left panel of Figure 2 shows that this conventional measure of marginal cost rises in response to the positive government spending shock. The standard measure of the markup, which is the inverse of this marginal labor cost, thus moves countercyclically in response to the demand shock, a feature that Rotemberg and Woodford (1992) have emphasized is important for models to replicate in order to generate realistic responses to demand shocks. We obtain this result with flexible prices, whereas most existing models that are able to generate this effect rely on nominal rigidities to do so. The reason this measure of the markup is countercyclical seems to be due to the tightening of the labor market. A tighter labor market gives the worker more leverage in wage bargaining. With workers able to extract a higher wage from employers and marginal output of the worker fixed, the marginal value of an employed worker, measured by the multiplier \( \mu_t \), falls to compensate for the rise in wage, as can be seen in (20).

### 5.2 Shutting Down the Intensive Margin

To focus on the effect of government spending shocks on the job-creation schedule, which, recall from the discussion in Section 4.3, is the way to think about labor demand in this model, we now shut down movements along the hours-worked margin by fixing hours. All labor market fluctuations
Figure 2: Response of labor market measures to one-percent positive government spending shock, which occurs in period 5. All variables, except \( \theta \), reported as deviation from steady-state.
are now at the extensive margin. In order to do this, we set \( h = 1 \) and remove condition (21) from the set of equilibrium conditions. Because the notion of the household’s MRS between labor and consumption is now ill-defined, we modify the wage equation to

\[
    w_t = \eta (mr_t z_t + \gamma \theta_t) + (1 - \eta) \left( \frac{A}{w'(c_t)} - \frac{b}{u'(c_t)} \right),
\]

where \( b \) is a utility parameter denoting the (constant) disutility of work if the household is employed.\(^{13}\) This wage equation, a linear relation between \( w \) and \( \theta \), is standard in models without intensive adjustment.

Figure 3 presents the response of labor market variables to the positive government spending shock with intensive adjustment suppressed. The responses of all the variables are similar to those in Figure 2, both qualitatively and in magnitude. As in the full model with both extensive and intensive adjustment, the real wage and tightness both rise. Here, the RBC-type intensive-labor-supply effect on wages present in our full model is absent, and adjustment clearly comes only through the extensive element of the job-creation condition (19).\(^{14}\) The wage curve (31), which is an upward-sloping linear schedule in \( w - \theta \) space, is the analog of the Walrasian labor supply schedule.

The fact that both \( w \) and \( \theta \) rise in Figure 3 means that the job-creation schedule shifts outward. To verify this, we plot in the top panel of Figure 4 the period-by-period equilibrium realizations of the wage and labor market tightness for a 100-period simulation of our model when shocks to \( g_t \) are the only driving process. As shown, the fluctuations in \( g_t \) cause shifts in only the job-creation condition because the equilibrium realizations trace out the linear wage curve (31). Fluctuations in job creation thus drive the dynamics of the labor market in the face of government spending shocks.

Finally, the lower panel of Figure 4 plots the equilibrium realizations of vacancies and unemployment in the model without intensive adjustment. As can be seen, fluctuations in \( g_t \) do not lead to the Beveridge relationship, which is an inverse relationship between vacancies and unemployment. Rather, shifts of the downward-sloping Beveridge curve in \( v - u \) space dominate shifts of the upward-sloping job-creation schedule in \( v - u \) space (see Pissarides (2000, p. 10)).

For comparison, we plot in Figure 5 the same information as in Figure 4 for the model with intensive adjustment operational. The full model also fails to generate a negative correlation

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\(^{13}\)Thus we also modify the instantaneous utility function to \( u(c_t) + \chi_t b + (1 - \chi_t) A \), where \( \chi_t = 1 \) if employed and \( \chi_t = 0 \) if unemployed. Without loss of generality, we set \( b = 0 \).

\(^{14}\)With \( h = 1 \) always, the job-creation condition in (19) simplifies a bit to \( \frac{\gamma}{q(\theta)} = \beta E_t \left[ \frac{\phi_{t+1}}{\phi_t} \right] (1 - \rho^s) \left( mr_{t+1} z_{t+1} - \frac{\partial W_{t+1}}{m_{t+1}} + \theta_{t+1} \frac{\partial W_{t+1}}{\partial \theta_{t+1}} \right) \). Note that the job-creation condition (19) of the full model is affected by adjustment at the intensive margin. That is, the decision to create vacancies depends on the (expected) number of hours in the full model.
Figure 3: Response of labor market measures in economy without intensive adjustment to one-percent positive government spending shock, which occurs in period 5. All variables, except $\theta$, reported as deviation from steady-state.
Figure 4: Model without intensive adjustment. Top panel: equilibrium realizations of wage and labor market tightness in simulated economy with \( \{g_t\} \) as the only exogenous process. Bottom panel: equilibrium realizations of vacancies and unemployment in simulated economy with \( \{g_t\} \) as the only exogenous process.
Figure 5: Model with intensive labor margin. Top panel: equilibrium realizations of wage and labor market tightness in simulated economy with \( \{ g_t \} \) as the only exogenous process. Bottom panel: equilibrium realizations of vacancies and unemployment in simulated economy with \( \{ g_t \} \) as the only exogenous process.

The top panels in Figure 3 show that by about five periods after the shock, both the wage and labor market tightness have fallen below their pre-shock steady-state values. The reason this happens is the influence of the real interest rate on job creation. Because consumption falls in the period of the shock before converging back to its steady state, the real interest rate along the deterministic transition back to steady state is above its pre-shock level. A rise in the real interest rate lowers the present-value of a match, the right-hand-side of condition (19), which decreases the attractiveness of creating vacancies. This effect of the real interest rate is always present, but dominated by the spillover effect on matching efficiency in the first several periods after the shock.

That the real interest rate effect dominates only farther away from the shock in our model highlights the way in which the results in this paper are different from Yuan and Li (2000). In their paper, the real interest rate is effectively the only shifter of job creation, implying that employment at the extensive margin falls in response to a rise in government purchases. Furthermore, their
model allows for adjustment at the intensive margin. Absent intensive adjustment, however, their model would counterfactually predict that output declines when government spending increases. Our model with no adjustment at the intensive margin predicts that output rises due to beneficial effect on matching efficiency. At the end of Section 6, we sever the link between government spending shifts and matching efficiency shifts to make this point.

6 Discussion

The countercyclical behavior of the labor markup is a central result of our model. Generating countercyclical movements in the markup has been a key focus of the theoretical literature studying the effects of government spending shocks. Most models that generate such an effect do so by relying on nominal rigidities in goods markets — see, for example, the results in Linnemann and Schabert (2003) and the references therein — which allow scope for a shift in (Walrasian) labor demand. More generally, most models tie variations in the markup to variations in the elasticity of demand for goods.\(^{15}\) In our model, the elasticity of demand for goods is always \(\varepsilon\).

Instead, we obtain time-variation in the markup through time-variation in the leverage that workers have in the wage-bargaining process. We find this a plausible explanation for why markups behave countercyclically over the business cycle: as the economy expands, the labor market tightens, giving workers leverage in wage negotiations that force employers to reduce their markup. As wages, which can be viewed as the flow cost of labor input, rise, the asset value of the marginal employee, measured in our model by \(\mu_t\), falls, as our results and condition (20) show. A useful analogy is with the \(q\) theory of investment in capital goods, of which one aspect is that as the rental cost \(r_t\) of capital, a flow cost, rises, the replacement value of installed capital, \(q_t\), falls. The value \(\mu_t\) can be thought of as the replacement value of an installed employee, a concept that has no analog in frictionless labor markets.

Finally, we point out that the link between positive government spending innovations and favorable shifts in the matching technology is important in generating a countercyclical markup. Our empirical results support such a link. If such a link does not exist, however, our model predicts that the job-creation schedule shifts inwards, rather than outwards, in response to a positive government spending shock. To show this, in Figures 6, 7, and 8, we repeat our basic experiments this time severing the link between shocks to \(g_t\) and shocks to \(\psi_t\) by setting the covariance between the shocks to zero. The responses in Figures 6 through 8 allow for adjustments along the intensive labor margin.

\(^{15}\) An example of a model that does not rely on nominal rigidities but still ties variations in the markup to variations in the elasticity of demand for goods is Ravn, Schmitt-Grohe, and Uribe (2006), who show that catching-up-with-Joneses preferences at the level of differentiated goods generates time-variation in the elasticity of demand for goods.
Figure 6: Model with no link between $g_t$ and $\psi_t$. Response of macro aggregates to one-percent positive government spending shock, which occurs in period 5. All variables reported as deviation from steady-state.
Figure 6 shows that the rise in output is entirely due to a rise in hours per job $h_t$, because employment $n_t$ actually declines. The increase along the intensive margin is simply the neoclassical mechanism at work, as households try to smooth the negative wealth effect on their consumption by being willing to work more hours, as described by, among others, Baxter and King (1993).

Figure 7 shows that firms post fewer, not more, vacancies without the positive spillover effect of increased government spending on labor matching, and both $w$ and $\theta$ decrease. Thus, the job-creation schedule shifts inwards when $g_t$ rises. The reason for this effect in the absence of the decline in mismatch is straightforward: a rise in the real interest rate (not shown) lowers the present-value of a match, the right-hand-side of condition (19), which decreases the attractiveness of creating vacancies. The reason the real interest rate rises is that consumption falls in the period of the shock before converging back to its steady-state. To induce the increased consumption growth rate along the deterministic transition path back to steady-state, the real interest rate must be above its steady-state level. As shown in the lower left panel of Figure 7, the markup does still move, albeit now procyclically. Marginal labor cost declines as workers have less leverage in negotiations due to a more slack labor market. Consequently, the value of employed workers, $\mu_t$, rises at the margin as the number of workers falls, shown in the lower right panel of Figure 7 shows. The analogy with the $q$ theory of investment in capital still holds.

Finally, Figure 8 shows that shifts in job creation still dominate shifts in the wage schedule (top panel), and a Beveridge Curve still fails to materialize (bottom panel). Taken together, we find effects of government spending absent the spillover effect on matching efficiency identical to those found by Yuan and Li (2000).

7 Conclusion

We have shown that if government spending acts as a coordination mechanism to temporarily reduce matching frictions in the labor market, a number of salient features of the effects of government spending shocks are predicted by our model. Most interestingly, we find a countercyclical markup as output expands following a positive government spending innovation. Our explanation for a countercyclical markup relies on neither nominal rigidities nor time-variation in the elasticity of demand for goods caused by some other mechanism. Rather, it is due to what we believe is a different plausible explanation: as the economy expands, the labor market tightens, giving workers increased leverage in wage negotiations, which forces employers to reduce their markup.

A number of extensions suggest themselves. First, a deeper way of modeling the spillover effect on match efficiency is an important pursuit. As we mentioned, Pissarides (2000) shows how variable search intensity on the part of individuals and variable advertising on the part of firms would show up in a reduced-form way as a shift in the matching efficiency parameter. We believe that a model
Figure 7: Model with no link between $g_t$ and $\psi_t$. Response of labor market measures to one-percent positive government spending shock, which occurs in period 5. All variables, except $\theta$, reported as deviation from steady-state.
Figure 8: Model with no link between $g_t$ and $\psi_t$. Top panel: equilibrium realizations of wage and labor market tightness in simulated economy with $\{g_t\}$ as the only exogenous process. Bottom panel: equilibrium realizations of vacancies and unemployment in simulated economy with $\{g_t\}$ as the only exogenous process.
in which firms advertise more heavily after being awarded a government contract and/or individuals search more effectively after hearing about the awarding of such a contract in their industry would generate the same effects our simpler model generates. Endogenizing the response in this way is of course theoretically attractive.

Shimer (2005) has recently raised the issue of whether wage determination according to Nash bargaining allows labor search models to match key labor market facts, in particular the volatility of vacancies and unemployment. Hall (2005a) proposes an alternative wage-determination mechanism that generates much less variability in wages and thus addresses some of Shimer’s (2005) concerns. Given that our countercyclical markup result stems from the movement of wages as market tightness fluctuates, we are interested to study how alternative wage determination schemes affect our results.

Another extension would be to consider a sectoral model in which government spending is concentrated in a particular sector and improves matching efficiency directly only in that sector, for example the defense sector. Indeed, our anecdotal story at the outset was a sectoral one. It would then be interesting to study the cross-sector effects as well as the aggregate effects of a government spending shock.

Finally, perhaps guided by which of the above extensions prove to be the most fruitful, more detailed empirical evidence on the effects of government spending surprises on matching efficiency, search intensity, job advertising, as well as probably a host of other labor market measures seems warranted. Our model’s quantitative predictions scratch the surface of what seems to be an understudied channel via which government spending shocks affect the economy, namely, that they propagate through frictional labor markets.
References


Table 1. Estimates of the effects of government spending on matching efficiency from an unidentified VAR. For each proxy of government spending, the first column presents results without imposing any restrictions on the estimated coefficients. The second column presents results imposing the restriction in equation 3 that the coefficient on the constant and the lag term sum to one.
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<td>$\alpha$</td>
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<td>0.002 (0.84)</td>
<td>0.005 (0.49)</td>
<td>-0.03 (-0.02)</td>
<td>0.008 (-0.35)</td>
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<td>$\beta_1$</td>
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<td>0.93 (0.33)</td>
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<td>$\beta_2$</td>
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<td>1.78 (0.03)</td>
<td>1.03 (0.00)</td>
<td>2.99 (0.00)</td>
<td>1.12 (0.07)</td>
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<td>$\gamma_1$</td>
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<td>. (0.69)</td>
<td>. (0.49)</td>
<td>. (0.54)</td>
<td>. (0.24)</td>
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<td>$\gamma_2$</td>
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Table 2. Estimates of the effects of government spending on matching efficiency from reduced form regressions.