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Fiscal Rules and Unemployment[†]

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Abstract

This paper analyzes fiscal policy under fiscal rules in a New Keynesian model with search and matching frictions and distortionary taxation. The model is estimated with US data including detailed information on fiscal instruments. Several findings stand out. First, fiscal rules enhance the positive effects of discretionary fiscal policy on output and unemployment if they influence the expected future path of interest rates. However, effects are smaller as suggested in the existing literature. Second, spending and consumption tax cuts have the largest multipliers. Third, multipliers for labor tax cuts are small. These results originate from the labor market friction and persist in an economy where the friction is more severe. Demand side disturbances explain the majority of labor market dynamics.

JEL Classification: E62, J20, H30, C11
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1 Introduction

Major economies face rising public debt levels and government debt crises threaten economic stability. Requests to consolidate public debt and to counteract economic downturns by fiscal stimulus have provoked an active debate on fiscal policy. It is well known that the size of government spending multipliers interacts with fiscal rules (Corsetti et al., 2012). These are typically evaluated in the context of neoclassical labor markets. However, one main policy objective is to prevent job losses. For an analysis of unemployment, a search and matching model is the natural choice. Several authors show that the assessment of the effects of fiscal policy may change in the presence of labor market frictions (Monacelli et al., 2010, Campolmi et al., 2011, Faia et al., 2013). In a search and matching labor market, variations in the labor tax transmit to the economy through wage bargaining over rents from long term employment relationships.[1]

This paper is the first to estimate a New Keynesian model with a frictional labor market and fiscal rules for various taxes and government expenditures on US data. The results reveal that government spending has the strongest effects on output and unemployment among all different fiscal policy instruments. Consumption tax cuts have sizable, but approximately half as large effects. In contrast, the reaction of output and unemployment to labor tax cuts is small. The main reason for the latter finding is that bargained wages do not respond strongly to labor tax cuts in the estimated model. This finding is unique to the estimated model with labor market frictions and new to the literature. Strong interest rate smoothing and a sluggish response of consumption compounds this effect. The fiscal rules enhance multipliers of discretionary fiscal policy. As stressed by Corsetti et al. (2012), under nominal rigidities, expected fiscal restraint in the future (in terms of lower spending and higher taxes), depresses inflation and interest rate expectations. Consequently, households optimally consume relatively more on impact. However, the structural estimation of fiscal rules highlights that the effects are smaller as suggested by Corsetti et al. (2012). Given that all fiscal instruments adjust to debt (and not only spending), private consumption is not crowded in in response to discretionary fiscal policy intervention.[2]

[1] Arseneau and Chugh (2012) show that the optimal fiscal policy design depends on the modeling of the underlying labor market and wage setting. Under search and matching frictions, changes in consumption and labor taxes may exhibit distinct effects. In a neoclassical labor market, consumption and labor income taxes distort the households' labor leisure decision in a similar way (given that aggregate savings have no intertemporal effects in a model without capital). Cooley and Hansen (1992) argue that consumption and labor taxes have quantitatively similar distortionary effects in a neoclassical model with capital. Leeper et al. (2010) find that the effects of tax shocks are similar even under fiscal rules.

[2] To my knowledge, this paper is the first to show that the amplification of fiscal multipliers from fiscal rules as suggested by Corsetti et al. (2012) exists if fiscal rules are structurally estimated in a DSGE model. Leeper et al. (2010) estimate similar fiscal rules but their model does not feature nominal rigidities. As a result, the Corsetti et al. (2012) effect does not exist. Forni et al. (2009) and Zubairy (2014) consider estimated tax rules, but not for govern-

Fiscal policy does not only act through discretionary intervention, but also through automatic stabilization. The model in this paper accounts for distinct forms of automatic stabilization. First, given that taxes are proportional to the tax base, tax revenue declines in a recession. Total unemployment benefits rise with unemployment. Second, the fiscal rules allow for counter cyclical fiscal policy. Spending, transfers and tax rates react automatically, or in a rule-based way, to the stance of the economy. The relative importance of the different components of automatic stabilization is controversial in the existing literature (in't Veld et al., 2013). Based on the estimated model with fiscal rules, this paper demonstrates that the additional stabilization of output and unemployment due to the latter component is small. This finding suggests that automatic stabilization arises mainly from the cyclicality of the tax base.

Given that the frictional labor market influences the effects of fiscal policy, I conduct a robustness analysis for a different labor market setting. An estimation for the German economy under collective wage bargaining, firing costs and smaller average flow rates illustrates that the above results hold even if the labor market is more rigid. Interestingly, fiscal multipliers are larger in Germany because wages respond less to market conditions.[3]

The structural estimation of a DSGE model with search and matching frictions contributes to the ongoing discussion about the driving forces of labor market dynamics. My results highlight that the majority of flow rate dynamics is triggered by demand side disturbances. Productivity shocks explain only a small fraction of labor market fluctuations. This finding confirms the recent notion that one explanation for the lack of sufficient amplification towards the labor market in search and matching models (Shimer, 2005) is the focus on productivity shocks only. The structural model estimation reveals that only a combination of supply and demand shocks replicates the unconditional correlations observed in the data.

I analyze fiscal policy in a New Keynesian DSGE model with search and matching frictions à la Mortensen and Pissarides (1994) with endogenous job destruction and Nash wage bargaining. As in Krause and Lubik (2007), the search and matching friction is incorporated in a New Keynesian setting with monopolistic competitors and price staggering due to Rotemberg (1982) adjustment costs. I extend this setting along the policy dimension. First, monetary policy follows a Taylor rule. At least since the discussion on policy at the zero lower bound, it is well known that the effects of fiscal policy depend on the interplay with monetary policy. As shown by Faia et al. (2014), monetary policy under labor market frictions should react to unemployment. Second, I introduce distortionay taxation of labor income, profits and con-

ment spending.

[3]This result is not only due to the different bargaining game (individual vs. collective bargaining), but mainly driven by the fact that US wages are very flexible and move close to one to one with marginal costs of production due to a relatively high bargaining power of workers. In Germany, wages are less responsive to changes in the marginal costs of production.

sumption (Faia et al., 2013). The government uses debt financing, whereas tax rates, transfers and government spending follow fiscal rules as in Corsetti et al. (2012). Under fiscal rules, fiscal instruments adjust not only to debt, but also to the business cycle (Leeper et al., 2010).

The exact specification of fiscal policy is contended in the the existing literature. For this reason, I let the data decide and estimate the model with detailed data on the fiscal sector using Bayesian techniques as in An and Schorfheide (2007). I compute effective tax rates following Mendoza et al. (1994). The combination with data on government spending and debt identifies fiscal policy along tax, spending, and debt dynamics. In contrast to the earlier literature, I assess fiscal policy at the intersection between data-driven structural vector autoregressions (SVARs) and purely calibrated DSGE models.[4] The previous empirical literature based on SVARs demonstrates that multipliers depend strongly on the identifying assumptions for fiscal shocks. Here, I use the structure of the DSGE model to identify the effects of fiscal policy in the data. In addition to the data on fiscal variables, I use detailed data on the labor market including job-finding and separation rates to clearly identify the labor market characteristics. As a result, my estimation does not only fit job creation, but also job destruction to the data.[5]

Based on the structure of the DSGE model and identified by detailed data on fiscal instruments and labor market characteristics, my results stress the benefits of government spending as a fiscal stimulus. Rising government spending by 1 percent of GDP increases output by 0.32 percent on impact. Unemployment is reduced by 0.37 percentage points if government spending goes up by one percentage point relative to GDP. Even though output multipliers are clearly below one as consumption is crowded out, the effect on unemployment is relatively sizable compared to existing estimates. The consumption tax multiplier is approximately half as large. Labor tax cuts are ineffective as multipliers are close to zero. In the more rigid German economy, fiscal multipliers are approximately twice as large compared to the US. In terms of the absolute size of the multipliers, the US numbers are at the lower end of output multipliers reported from SVARs (Hall, 2010). The results of Monacelli et al. (2010) on unemployment multipliers are comparable to the ones here. Estimates of tax multipliers vary widely, but my results question the large tax multipliers identified by Mountford and Uhlig (2009).

From the theoretical perspective, my approach is closest to Campolmi et al. (2011) and

[4] Other studies examining fiscal multipliers in estimated DSGE models are Leeper et al. (2010) and Zubairy (2014) for the US and Forni et al. (2009) for the Euro area. However, these studies do not allow for a frictional labor market and unemployment. Leeper et al. (2010) use a RBC model that does not permit to explore the interdependency of fiscal and monetary policy. Forni et al. (2009) and Zubairy (2014) do not allow for spending reversals.

[5] Several studies stress the importance of the endogenous separation margin (e.g., Fujita, 2011). Recent papers estimating DSGE models with labor market frictions are Gertler et al. (2008), Krause et al. (2008), Sala et al. (2008), Christoffel et al. (2009), Trigari (2009), Thomas and Zanetti (2009), Christiano et al. (2011) and Galí et al. (2011). However, most of these papers concentrate on monetary policy and inflation and none of them examines fiscal policy and rules explicitly. Furthermore, they do also not use flow rate data.

Faia et al. (2013). Campolmi et al. (2011) do not allow for endogenous job separations and do not estimate their model. In contrast to Faia et al. (2013), I use a search and matching friction instead of a labor selection mechanism. I extend the modeling of the fiscal sector and transfer the setting to an US style economy. Mayer et al. (2010) and Brückner and Pappa (2012) also assess fiscal policy in models featuring unemployment. My results contribute to this literature as I, first, add important features to the model (endogenous separations, a rich fiscal sector and multi-dimensional fiscal rules), and, second, take the model as close as possible to the data with the Bayesian estimation.

The remainder of the paper is organized as follows. Section 2 presents the model with search and matching frictions and a rich fiscal sector. Section 3 describes the estimation strategy including a detailed account of the data and priors. Section 4 discusses the estimation results, model fit, and the structural variance decomposition. Section 5 examines the effects of policy intervention. Section 6 concludes.

2 The model

The model is a basic New Keynesian setting with Rotemberg (1982) adjustment costs. The model is augmented with a labor market characterized by search and matching frictions with endogenous separations as in Krause and Lubik (2007) and a rich fiscal sector as in Faia et al. (2013). Labor is adjusted along the extensive margin only. This prevalent assumption in the literature is justified by the observation that hours are mostly adjusted along the extensive margin (Merkl and Wesselbaum, 2011). As common in the literature on labor market frictions, I abstract from capital as an additional production factor.[6]

2.1 Households

Households maximize expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t d_t \frac{c_t^{1-\sigma}}{1-\sigma}, \tag{1}$$

choosing consumption c_t and bonds B_t subject to the budget constraint

$$(1+\tau_t^c)c_t + \frac{B_t}{p_t} = (1-\tau_t^n)w_t n_t + bu_t + (1-\tau_t^p)\Pi_t - \frac{\tau_t^{ls}}{p_t} + (1+i_{t-1})\frac{B_{t-1}}{p_t}. \tag{2}$$

[6] Another interpretation is that the capital stock is constant in the short run. Moreover, I assume constant returns to scale in labor. Compare, e.g., Trigari (2009) and Krause and Lubik (2007) for comparable model setups.

The intertemporal preference shock d_t captures demand shifts and follows an exogenous AR(1) process $\log d_t = \rho_d \log d_{t-1} + \epsilon_t^d$ with $\rho^d \in [0,1]$ and $\epsilon_t^d \sim$ iid $N(0, \sigma_d^2)$.[7] Households earn aggregate labor income $w_t n_t$ and receive unemployment benefits, b, for unemployed members $u_t = 1 - n_t$.[8] Labor supply is inelastic as employment is determined by a search and matching process and leisure does not enter the households' utility function. Households receive real profits, Π, from the firms and lump-sum transfers, τ^{ls}, from the government (e.g., social transfers). They pay taxes on consumption, τ^c, labor income, τ^n, and profits, τ^p.[9] Last periods' bonds pay the net nominal interest rate, i_{t-1}, today. The price index is denoted by p_t.

Optimal household behavior implies

$$\lambda_t = \frac{c_t^{-\sigma}}{1 + \tau_t^c}, \tag{3}$$

where λ_t is the marginal utility of consumption and

$$\lambda_t = E_t \beta \frac{d_{t+1}}{d_t} (1 + i_t) \lambda_{t+1} \frac{p_t}{p_{t+1}}. \tag{4}$$

2.2 Production

For illustrative purposes, production is split in three parts as in Trigari (2009) or Faia et al. (2013).

Step 1: Intermediate goods producers sell homogeneous goods in a perfectly competitive market, but are subject to search and matching frictions in employing labor.

Step 2: The wholesale sector buys the intermediate goods and transforms them into differentiated consumption goods. Wholesalers sell under monopolistic competition and are subject to Rotemberg adjustment costs when adjusting prices.

Step 3: Retailers combine the differentiated goods of the wholesale sector into a final consumption aggregate and sell them to households under perfect competition.

[7] Among others, Hall (1997) argues that preference shocks are important for labor market dynamics. The formulation here follows Forni et al. (2009) and Leeper et al. (2010) in the fiscal policy context, and Gertler et al. (2008), Krause et al. (2008) and Sala et al. (2008) in the search and matching context. Christoffel et al. (2009) introduce demand shifts by adding a time varying risk premium to bond returns.

[8] As common in the literature, I assume households are so large that members perfectly insure each other against income fluctuations (Andolfatto, 1996 and Merz, 1995). As a result, consumption is the same regardless of whether one works or is unemployed.

[9] Profit taxes are taxes on profits of monopolistic competitors and intermediate firms that emerge from the labor market friction. This representation is a short cut to capture distortions along the firms' profit margin in a model without capital.

2.2.1 Intermediate goods producers and the labor market

Intermediate goods producers employ homogeneous labor to produce the intermediate good z_t with

$$z_t = a_t n_t. \tag{5}$$

Aggregate productivity a_t and follows an exogenous AR(1) process $\log a_t = \rho_a \log a_{t-1} + \epsilon_t$ with $\rho_a \in [0,1]$ and $\epsilon \sim$ iid $N(0, \sigma_a^2)$. Intermediate producers sell in a competitive market and their real relative price equals marginal costs $mc_t = \frac{p_{z,t}}{p_t}$.

Employment n_t is determined on a labor market characterized by search and matching frictions. Timing is as follows: each firm inherits n_{t-1} workers from the last period. The end of last period unemployed u_{t-1} search for a job in the current period. Firms post vacancies v_t to increase their current employment stock. Existing and new matches are then subject to exogenous separation risk ϕ^x. If the match survives, the match is hit by idiosyncratic productivity shocks that may result in endogenous separation at rate ϕ_t^e. The total separation rate is $\phi_t = \phi^x + (1-\phi^x)\phi_t^e$. Wages are determined from Nash bargaining. New matches become productive immediately. Employment at the end of period t is given by $n_t = (1-\phi_t)n_{t-1} + (1-\phi_t)\eta_t u_{t-1}$, where η_t denotes the quarterly job-finding rate.

New matches m_t evolve from a standard Cobb-Douglas matching function

$$m_t = \mu_t u_{t-1}^{\alpha} v_t^{1-\alpha}, \tag{6}$$

where $0 < \alpha < 1$ is the matching elasticity with respect to unemployment and $\mu_t > 0$ represents a stochastic process of aggregate matching efficiency with $\mu_t/\mu = (\mu_{t-1}/\mu)^{\rho_\mu} \exp(\epsilon_t^\mu)$. This process is characterized by steady state matching efficiency μ, $\rho_\mu \in [0,1]$ and $\epsilon^\mu \sim$ iid $N(0, \sigma_\mu^2)$.[10] As a result, vacancies are filled with probability $q(\theta_t) = m_t/v_t = \mu_t \theta_t^{-\alpha}$ with labor market tightness $\theta_t = v_t/u_{t-1}$. An unemployed worker finds a job in period t at rate $\eta_t = m_t/u_{t-1} = \theta_t q(\theta_t) = \mu_t \theta_t^{1-\alpha}$.

Matches are separated exogenously (quits) and endogenously (firings) as in Krause and Lubik (2007). Endogenous separations at rate ϕ_t^e occur as follows. In each period, existing and new worker-firm pairs are hit by idiosyncratic random shocks ε to current profits with time-invariant pdf $g(\varepsilon)$ and cdf $G(\varepsilon)$. I assume that idiosyncratic shocks are additive. As a result, contemporaneous profits of a match may be negative.[11] Endogenous

[10] The aggregate matching efficiency is treated as an exogenous parameter in the baseline search and matching model. I introduce stochastic fluctuations in matching efficiency μ_t as in Krause et al. (2008) or Lubik (2009) to capture stochastic disturbances in the labor market itself.

[11] The main results do not change under multiplicative idiosyncratic shocks.

separations generate firing costs denoted by f. The value of a match for the firm after the shock realization ε is known is

$$\tilde{J}_t(\varepsilon) = \Big(a_t mc_t - \varepsilon_t - w_t(\varepsilon_t)\Big)(1-\tau_t^p) + E_t\Lambda_{t,t+1}J_{t+1}. \tag{7}$$

The worker-firm pair knows at this stage that they are not exogenously separated. The expected stochastic discount factor is $E_t\Lambda_{t,t+1} = \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\frac{d_{t+1}}{d_t}$ and $w_t(\varepsilon)$ denotes individual wages that depend on the idiosyncratic shock realization ε. The future value of a match for the firm is given by

$$\begin{aligned} E_t J_{t+1} =& E_t(1-\phi_{t+1})\int_{-\infty}^{v_{t+1}^f} \frac{\big(a_{t+1}mc_{t+1} - \varepsilon_{t+1} - w_{t+1}(\varepsilon_{t+1})\big)g(\varepsilon)}{1-\phi_{t+1}^e} d\varepsilon_{t+1}(1-\tau_{t+1}^p) \\ &- E_t\Big[(1-\phi^x)\phi_{t+1}^e\big(f(1-\tau_{t+1}^p) + V_{t+1}\big) + \phi^x V_{t+1} + (1-\phi_{t+1})\Lambda_{t+1,t+2}J_{t+2}\Big]. \end{aligned} \tag{8}$$

The first term captures the expected profits of the match in period $t+1$, i.e., aggregate revenue minus expected idiosyncratic costs and expected wages, given that no separation occurs.[12] Production is priced at marginal costs given that intermediate good produces sell on a perfectly competitive market. The second term represents the firing costs that the firm has to pay in case of endogenous separation plus the value of a vacancy. The third term captures the value of a vacancy in case of exogenous separation. The last term represents the expected discounted future value of the continued match in case of no separation. Vacancy posting induces vacancy posting costs $\kappa > 0$. New hires turn productive immediately (instantaneous hiring). Consequently, the value of a vacancy is

$$V_t = -\kappa(1-\tau_t^p) + q(\theta_t)J_t + \big(1-q(\theta_t)\big)E_t\Lambda_{t,t+1}V_{t+1}. \tag{9}$$

As usual, I assume free entry in vacancy posting. Consequently, firms enter the market until the value of a vacancy is zero ($V_t = 0\ \forall t$) and

$$J_t = \frac{\kappa(1-\tau_t^p)}{q(\theta_t)}. \tag{10}$$

With the definition of the value of a job (Eq. 8), this equation defines the job creation condition

[12] Note that the conditional expected revenue depends on the density of ε conditional on not endogenously separating. This conditional density can be expressed as $g(\varepsilon|\varepsilon_{t+1} < v_{t+1}^f) = \frac{g(\varepsilon)}{G(v_{t+1}^f)} = \frac{g(\varepsilon)}{1-\phi_{t+1}^e}$.

as

$$\frac{\kappa(1-\tau_t^p)}{q(\theta_t)} =(1-\phi_t)\int_{-\infty}^{v_t^f}\frac{\big(a_t mc_t-\varepsilon_t-w_t(\varepsilon_t)\big)g(\varepsilon)}{1-\phi_t^e}d\varepsilon_t(1-\tau_t^p) \\ -(1-\phi^x)\phi_t^e f(1-\tau_t^p)+(1-\phi_t)E_t\Lambda_{t,t+1}\frac{\kappa(1-\tau_{t+1}^p)}{q(\theta_{t+1})}. \tag{11}$$

Workers are fired if the costs incurred by retaining the match are larger than the firing costs, i.e., $(a_t mc_t - w_t(\varepsilon_t)-\varepsilon)(1-\tau_t^p)+E_t\Lambda_{t,t+1}J_{t+1} < -f(1-\tau_t^p)$. As a result, the endogenous firing threshold is

$$v_t^f = a_t mc_t - w_t(v_t^f)+\frac{1}{1-\tau_t^p}E_t\Lambda_{t,t+1}J_{t+1}+f \tag{12}$$

and the endogenous separation rate is $\phi_t^e=\int_{v_t^f}^{\infty}g(\varepsilon)d\varepsilon_t = 1-G(v_t^f)$.

2.2.2 Wage determination

Each firm bargains with each worker individually to split the surplus of a match by Nash bargaining. The wage maximizes the Nash product $(\tilde{J}_t(\varepsilon_t)-V_t+f)^{1-\gamma}(W_t(\varepsilon_t)-U_t)^{\gamma}$.[13] The workers' bargaining power is denoted by γ. The value of match for the worker with shock realization ε is

$$W_t(\varepsilon_t)=w_t(\varepsilon_t)(1-\tau_t^n)+E_t\Lambda_{t,t+1}\Big[\phi_{t+1}U_{t+1}+(1-\phi_{t+1})\int_{-\infty}^{v_{t+1}^f}\frac{W_{t+1}(\varepsilon_{t+1})}{1-\phi_{t+1}^e}g(\varepsilon)d\varepsilon_{t+1}\Big] \tag{13}$$

and the value of an unemployed worker is

$$U_t=b+E_t\Lambda_{t,t+1}\Big[\eta_{t+1}(1-\phi_{t+1})\int_{-\infty}^{v_{t+1}^f}\frac{W_{t+1}(\varepsilon_{t+1})}{1-\phi_{t+1}^e}g(\varepsilon)d\varepsilon_{t+1}+\big(1-\eta_{t+1}(1-\phi_{t+1})\big)U_{t+1}\Big]. \tag{14}$$

[13] The wage derivation is only sketched here. Details can be found in Appendix A. Note that I include firing costs in the wage bargaining and in the value of a job. This proceeding disrespect the bonding critique (see Ahrens and Wesselbaum, 2009 for a discussion).

As a result, the bargained wage for each realization of the idiosyncratic shock ε_t is

$$
\begin{aligned}
w_t(\varepsilon_t) =&\gamma\Big[a_t mc_t - \varepsilon_t + E_t\Lambda_{t,t+1}\frac{\kappa}{q(\theta_{t+1})}\Big(\frac{1-\tau^p_{t+1}}{1-\tau^p_t} - (1-\eta_{t+1})\frac{1-\tau^n_{t+1}}{1-\tau^n_t}\Big) \\
&- E_t\Lambda_{t,t+1}(1-\phi_{t+1})(1-\eta_{t+1})\frac{1-\tau^n_{t+1}}{1-\tau^n_t}\frac{f}{1-\tau^p_{t+1}}\Big] + (1-\gamma)\frac{b}{1-\tau^n_t}. \qquad (15)
\end{aligned}
$$

The aggregate wage is the mean of individual wages weighted with the idiosyncratic shock distribution

$$
\begin{aligned}
w_t =& \int_{-\infty}^{v^f_t} w_t(\varepsilon_t) g(\varepsilon|\varepsilon < v^f_t) d\varepsilon_t = \int_{-\infty}^{v^f_t} w_t(\varepsilon_t)\frac{g(\varepsilon)}{1-\phi^e_t} d\varepsilon_t \\
=&\gamma\Big[a_t mc_t - \int_{-\infty}^{v^f_t}\varepsilon_t\frac{g(\varepsilon)}{1-\phi^e_t}d\varepsilon_t + E_t\Lambda_{t,t+1}\frac{\kappa}{q(\theta_{t+1})}\Big(\frac{1-\tau^p_{t+1}}{1-\tau^p_t} - (1-\eta_{t+1})\frac{1-\tau^n_{t+1}}{1-\tau^n_t}\Big) \\
&- E_t\Lambda_{t,t+1}(1-\phi_{t+1})(1-\eta_{t+1})\frac{1-\tau^n_{t+1}}{1-\tau^n_t}\frac{f}{1-\tau^p_{t+1}}\Big] + (1-\gamma)\frac{b}{1-\tau^n_t}. \qquad (16)
\end{aligned}
$$

2.2.3 Wholesalers and retailers

Monopolistic wholesalers, indexed by (i), adjust their prices $p(i)$ every period subject to quadratic Rotemberg (1982) adjustment costs maximizing

$$
E_0\sum_{t=0}^{\infty}\Lambda_{t,t+1}(1-\tau^p_t)\Big[\frac{p_t(i)}{p_t}\tilde{y}_t(i) - mc_t\tilde{y}_t(i) - \frac{\Psi}{2}\Big(\frac{p_t(i)}{p_{t-1}(i)} - 1\Big)^2\tilde{y}_t\Big], \qquad (17)
$$

where Ψ measures price adjustment costs. In equilibrium, total production is $\tilde{y}_t = a_t n_t$. Retailers aggregate with a CES production function $\tilde{y}_t = \big(\int_0^1 \tilde{y}_t(i)^{\frac{\nu_t-1}{\nu_t}} di\big)^{\frac{\nu_t}{\nu_t-1}}$, where ν_t is the time-varying elasticity of substitution between individual goods, $\tilde{y}_t(i)$. Each individual wholesale firm faces downward sloping demand $\tilde{y}_t(i) = \Big(\frac{p_t(i)}{p_t}\Big)^{-\nu_t}\tilde{y}_t$ in individual prices. Optimal price setting follows[14]

$$
\Psi(\pi_t - 1)\pi_t = (1-\nu_t) + \nu_t mc_t + E_t\Big[\Lambda_{t,t+1}\Psi(\pi_{t+1}-1)\frac{\tilde{y}_{t+1}}{\tilde{y}_t}\frac{1-\tau^p_{t+1}}{1-\tau^p_t}\pi_{t+1}\Big]. \qquad (18)
$$

Due to the labor market friction, real marginal costs of production mc differ from marginal costs in a perfectly competitive market. They capture the long run value of a match.[15] The

[14] Appendix A shows the full derivation.

[15] Compare Faia et al. (2013) for a discussion. Given that marginal costs generate inflation dynamics, their different nature under labor market frictions has been discussed in detail in the literature on monetary policy (Krause and Lubik, 2007, Trigari, 2009).

time-varying elasticity of substitution ν_t captures price mark-up shocks. They evolve as $\frac{\varphi_t}{\varphi} = (\frac{\varphi_{t-1}}{\varphi})^{\rho_\varphi} \exp(\epsilon_t^\varphi)$ with $\varphi_t = \nu_t/(\nu_t - 1)$, $\rho_\varphi \in [0,1]$ and $\epsilon^\varphi \sim$ iid $N(0, \sigma_\varphi^2)$.[16]

2.3 Fiscal and monetary policy

The government finances spending, g, unemployment benefits, b and transfers, τ^{ls}, through tax revenues and issuing debt, D. The model includes distortionary labor taxes, τ^n, consumption taxes, τ^c, and profit taxes, τ^p. Lump-sum transfers, τ^{ls}, can be interpreted as the conventional lump-sum tax in models without fiscal rules. The government budget constraint is

$$g_t + bu_t + \frac{1+i_{t-1}}{\pi_t} D_{t-1} = \tau_t^{ls} + \tau_t^n w_t n_t + \tau_t^c c_t + \Pi_t \tau_t^p + D_t. \tag{19}$$

Fiscal policy follows fiscal rules in the spirit of Leeper et al. (2010) and Corsetti et al. (2012). The fiscal rules are multi-dimensional as all policy instruments respond to government debt and output. First, government spending and tax rates react to the overall debt level. Second, I allow for automatic stabilization of tax rates, transfers and spending as all fiscal instruments respond to the output gap. Third, Leeper et al. (2010) argue that policy makers often consider changes in tax rates jointly. In line with their specification, shocks in one tax rate affect other tax rates contemporaneously. Here, all fiscal instruments adjust in order to consolidate debt (Leeper et al., 2010). The estimation determines the exact share that each instruments takes over.

The policy rule for government spending is

$$\frac{g_t}{g} = (\frac{g_{t-1}}{g})^{\rho_g} (\frac{D_{t-1}}{D})^{-\psi_{g,d}} (\frac{y_t}{y})^{-\psi_{g,y}} \exp(\epsilon_t^g). \tag{20}$$

Lump-sum transfers evolve as

$$\frac{\tau_t^{ls}}{\tau^{ls}} = (\frac{\tau_{t-1}^{ls}}{\tau^{ls}})^{\rho_{\tau^{ls}}} (\frac{D_{t-1}}{D})^{-\psi_{\tau^{ls}}} (\frac{y_t}{y})^{-\psi_{\tau^{ls},y}} \exp(\epsilon_t^{\tau^{ls}}), \tag{21}$$

and rules for tax rates are given by

$$\frac{\tau_t^i}{\tau^i} = (\frac{\tau_{t-1}^i}{\tau^i})^{\rho_{\tau^i}} (\frac{D_{t-1}}{D})^{\psi_{\tau^i}} (\frac{y_t}{y})^{\psi_{\tau^i,y}} \exp(\epsilon_t^{\tau^i}) \prod_{\substack{j=\{w,k,c\} \\ j \neq i}} \exp(\zeta_{i,j} \epsilon_t^{\tau^j}), \tag{22}$$

[16] This formulation follows Thomas and Zanetti (2009) and is, among others, also applied in Krause et al. (2008), Sala et al. (2008), Gertler et al. (2008), Christoffel et al. (2009), and Forni et al. (2009). Price mark-up shocks are necessary to explain the dynamics of economic data, in particular inflation (e.g., Del Negro and Schorfheide, 2006). They capture the labor wedge as described by Chari et al. (2007).

for $i = \{w, k, c\}$. The speed of adjustment of each fiscal instrument to government debt is determined by the $\psi_{\cdot,d}$ parameters. The $\psi_{\cdot,y}$ parameters capture the response of each fiscal instrument to the deviation of output from steady state. Shocks to government spending, tax rates and transfers are given by ϵ^g and ϵ^{τ^i} for $i = \{ls, w, k, c\}$ and are specified as iid $N(0, \sigma_j^2)$ with $\rho_j \in [0, 1]$ for $j = \{g, ls, w, k, c\}$. The contemporaneous correlation of tax rate s and t is captured by the $\zeta_{s,t}$ coefficient. The shocks to fiscal instruments represent discretionary fiscal policy changes.

Monetary policy follows a Taylor (1993) rule

$$\frac{1+i_t}{1+i} = \left(\frac{1+i_{t-1}}{1+i}\right)^{\rho_i} \left[\left(\frac{\pi_t}{\pi}\right)^{\xi_\pi} \left(\frac{y_t}{y}\right)^{\xi_y} \left(\frac{u_t}{u}\right)^{\xi_u}\right]^{1-\rho_i} \exp(\epsilon_t^m). \tag{23}$$

The Taylor rule has been used in a number of different studies as it provides a good description of monetary policy (Smets and Wouters, 2007). The central bank reacts to deviations from steady state of inflation, output and unemployment, but smooths interest rates. The Taylor rule response to unemployment addresses the trade off between unemployment and inflation for optimal monetary policy under labor market frictions (see Blanchard and Galí, 2010, Faia, 2008, or Faia et al., 2014). The monetary policy shock ϵ^m is distributed iid $N(0, \sigma_m^2)$.

2.4 Aggregation and resource constraint

Aggregate real profits (before taxes) in this economy are defined by the sum of aggregate profits of intermediate firms ($mc_t a_t n_t - w_t n_t - n_{t-1}\phi_t^e f - n_t \int_{-\infty}^{v_t^f} \varepsilon_t g(\varepsilon) d\varepsilon_t - \kappa v_t$) and the wholesale sector ($\tilde{y}_t - mc_t a_t n_t - \frac{\Psi}{2}(\pi_t - 1)^2 \tilde{y}_t$). Perfectly competitive retailers make zero profits. Real profits are

$$\Pi_t = \tilde{y}_t - w_t n_t - n_{t-1}\phi_t^e f - n_t \int_{-\infty}^{v_t^f} \varepsilon_t g(\varepsilon) d\varepsilon_t - \kappa v_t - \frac{\Psi}{2}(\pi_t - 1)^2 \tilde{y}_t. \tag{24}$$

The resource constraint (using the household's and the government's budget constraint and equilibrium in the bond market) is defined as

$$c_t + g_t = \tilde{y}_t - n_{t-1}\phi_t^e f - n_t \int_{-\infty}^{v_t^f} \varepsilon_t g(\varepsilon) d\varepsilon_t - \kappa v_t - \frac{\Psi}{2}(\pi_t - 1)^2 \tilde{y}_t. \tag{25}$$

Private and public consumption equals production $\tilde{y}_t$ minus resource costs for firing, aggregate profitability shocks, vacancy posting and price adjustment. The sum of private and public consumption defines output (or GDP) y_t as

$$y_t = c_t + g_t. \tag{26}$$

3 Estimation and calibration

I estimate the log-linearized model with Bayesian techniques as described, e.g., in the survey by An and Schorfheide (2007). The mode of the posterior distribution is obtained using numerical maximization and the full posterior is explored with the Random Walk Metropolis Hastings algorithm.[17]

3.1 Data and measurement

The model is estimated with quarterly US data on GDP, inflation and interest rates. As labor market variables, I include the job-finding and the separation rate computed as by Shimer (2012). The fiscal sector is characterized by series on government spending, government debt and tax rates. The series span from 1965Q1 to 2011Q4.[18] Inflation and interest rates are demeaned. GDP, flow rates, spending, debt and tax rates are filtered with the one-sided HP filter of Stock and Watson (1999) (in logs).[19] These observables are matched with their model counterparts using log deviations from steady state. The model features ten structural shocks for ten observable variables: shocks to aggregate productivity, ϵ, monetary policy, ϵ^m, government spending, ϵ^g, shocks to each tax rate, ϵ^{τ^w}, ϵ^{τ^c}, ϵ^{τ^k}, shocks to lump-sum transfers, $\epsilon^{\tau^{ls}}$, preference shocks, ϵ^d, price-mark up shocks, ϵ^ν and shocks to the matching efficiency, ϵ^μ. The measurement equation $\mathbf{y}_t = H(\mathbf{\Theta})\mathbf{x}_t$ links the vector $\mathbf{x}_t$ of model variables and structural shocks and the vector of observables $\mathbf{y}_t$. The vector $\mathbf{\Theta}$ collects all structural parameters.

3.2 Discussion of priors and identification

Table 1 summarizes the steady state targets and the fixed parameters. These very strict priors reflect that the estimation is not informative for these values. The steady state targets of the model correspond to averages in the data. The average real return is 2.27 percent (as derived from inflation and nominal interest rates). The corresponding discount factor, β, is 0.994. Steady

[17] At the mode, I checked the gradient by inspecting the shape of slices of the likelihood and the posterior. I ensure convergence of the Markov chain by diagnostic tools such as CUSUM and trace plots.

[18] Appendix B discusses data sources and the construction of effective tax rates in more detail. The sample includes the Great Recession. The general results remain unchanged if the Great Recession period is excluded given that the sample is very long with almost 50 years of data.

[19] As also discussed by Jones (2002), the tax rates exhibit long run trends that have no representation in the model. The HP filter removes these trends.

state gross inflation is normalized to unity. Unemployed workers find a job at an average rate of 79.4 percent. Employed workers are separated at an average rate of 9.75 percent. In line with den Haan et al. (2000), exogenous separations constitute two thirds of total separations. I target the steady state job-finding rate with the vacancy posting costs κ. The target for the separation rate is met by adjusting the variance of the idiosyncratic shock distribution $g(\varepsilon)$. I assume that the idiosyncratic shocks follow a logistic distribution with mean $a_1 = 0$ and scale parameter a_2. The logistic distribution allows to derive closed form solutions for the expected shock realizations.[20] Following den Haan et al. (2000), the average quarterly worker finding rate is set to 70 percent. This target is matched with the steady state matching efficiency. Firing costs are set to zero.

		Value
Discount factor	β	0.9944
Elasticity of substitution	ν	10
Firing costs	f	0
Mean of idiosyncratic shock distribution	a_1	0
Gross inflation	π	1
Job-finding rate	η	0.7939
Separation rate	ϕ	0.0975
Worker finding rate	$q(\theta)$	0.7
Exogenous separations	ϕ^x	0.065
Government spending (relative to GDP)	g/y	0.2081
Government debt (relative to GDP)	D/y	0.3199
Labor tax rate	τ^n	0.2543
Profit tax rate	τ^k	0.3907
Consumption tax rate	τ^c	0.0518

Table 1: Fixed parameters and steady state targets. Quarterly calibration. Annual productivity is normalized to 1.

The methods of Iskrev (2010b) allow to check parameter identification.[21] Most parame-

[20]To be precise here, targeting flow rates does not mean that the scale parameter of the logistic distribution and the vacancy posting costs are fixed during the estimation. Instead, analytic expression for these parameters that depend on the targets and on the deep parameters from the steady state representation of the model allow to update these two parameters, while the deep parameters are estimated.

[21]Recently, the problem of parameter identification in DSGE models has gained attention in the literature (e.g., Canova and Sala, 2009). Here, I follow Iskrev (2010b) who derives conditions for identification based on the Jacobian matrix of the first and second order moments of the observables to the structural parameters of the model. Additionally, Iskrev (2010a) discusses how to evaluate weak parameter identification based on the Fisher information matrix, i.e., the second moments of the partial derivative of the log-likelihood function with respect to the structural parameters. A parameter is identified if the likelihood is not completely flat with respect to this parameter. Weak identification implies that the likelihood has a very low curvature and parameters are estimated in a very imprecise way.

ters, especially those of the fiscal rules, are well identified. However, the steady state demand elasticity ν and price adjustment cost Ψ are collinear in the model and only weakly identified. Smets and Wouters (2007) document the same observation. In line with Smets and Wouters (2007), I set a very tight prior for the demand elasticity and estimate only the price adjustment costs Ψ. The steady state elasticity of substitution between different product types ν is set to 10 (Faia et al., 2013).

All remaining parameters are estimated. The prior distributions are summarized in Table 2. Priors for labor market parameters follow Lubik (2009). Prior distributions are rather wide and cover a broad region of reasonable parameter values, in particular, for the matching elasticity α, workers' bargaining power γ, and the replacement rate $rr = b/w$. A Beta prior with mean 0.5 and standard deviation 0.2 reflects that these parameters are bounded between zero and one.

		Density	Mean	Std.dev.
Labor market				
Matching elasticity on unemployment	α	Beta	0.5	0.2
Bargaining power of the worker	γ	Beta	0.5	0.2
Replacement rate	rr	Beta	0.4	0.2
Price setting, monetary policy, and preferences				
Price adjustment costs	Ψ	Normal	100	$1000^{1/2}$
Interest rate smoothing	ρ_i	Beta	0.75	0.1
Taylor rule response to inflation	ξ_π	Normal	1.7	0.1
Taylor rule response to output	ξ_y	Normal	0.125	0.05
Taylor rule response to unemployment	ξ_u	Normal	-0.2	0.25
Relative risk aversion	σ	Gamma	2	0.5
Fiscal policy				
Feedback of gvmt. debt on gvmt. spending	$\psi_{g,d}$	Gamma	0.4	0.2
Feedback of output on gvmt. spending	$\psi_{g,y}$	Gamma	0.07	0.05
Feedback of gvmt. debt on each tax rate	ψ_{τ^j}	Gamma	0.4	0.2
Feedback of output on labor tax	$\psi_{\tau^w,y}$	Gamma	0.5	0.25
Feedback of output on profit tax	$\psi_{\tau^k,y}$	Gamma	1	0.3
Feedback of output on consumption tax	$\psi_{\tau^c,y}$	Gamma	0.05	0.025
Feedback of output on transfer	$\psi_{\tau^{ls},y}$	Gamma	0.2	0.1
Co-movement of shocks to tax rates	$\zeta_{j,k}$	Normal	0.25	0.1
Shock processes				
AR-coefficients of shocks (fixed at zero in case of monetary policy shock)	ρ_j	Beta	0.5	0.2
Std.dev. of shocks	σ_j	Inv. Gamma	0.01	1

Table 2: Estimated parameters and prior distributions. Quarterly calibration.

The risk aversion parameter follows a Gamma distribution centered at 2 with standard deviation 0.5. This prior captures values typically used in the literature (e.g., Christoffel et al., 2009 or Faia et al., 2013). Priors for the monetary policy parameters are in line with Smets and Wouters (2003) and Gertler et al. (2008), among others. The prior mean for the Taylor coefficient on inflation is 1.7.[22] The prior mean for the output response is 0.125, which corresponds to a Taylor coefficient of 0.5 with annualized inflation. The optimal Taylor coefficient on unemployment differs depending on the type of labor market friction introduced in the model. Faia (2008) finds an optimal coefficient of -0.15 with search and matching unemployment, Blanchard and Galí (2010) argue in favor of -0.8 for the US and -0.6 for Europe. A Normal prior with mean -0.2 and standard deviation 0.25 covers all these values. Evidence on the average duration of a price contract varies between 2 and 4 quarters. I set a broad Normal prior centered at 100 with standard deviation $1000^{1/2}$ (Forni et al., 2009).[23]

The priors for the fiscal policy parameters follow Leeper et al. (2010) who discuss in detail that the values cover estimates from previous research. All fiscal elasticities follow Gamma distributions. The elasticities with respect to government debt are centered at 0.4 with standard deviation 0.2.[24] The value of 0.02 used by Corsetti et al. (2012) is included in the prior range. The prior mean of the spending and transfer elasticity for the automatic response to output is rather small, whereas profit and labor taxes respond rather strongly. I allow for automatic stabilization in consumption taxes. A prior mean of 0.05 captures that these effects are potentially small. The parameters for the co-movement between shocks to tax rates follow Normal distributions with mean 0.25 and standard deviation 0.1. Finally, the prior standard deviations of the structural shocks are inverse Gamma distributed with mean 0.01 and standard deviation 1 (Krause et al., 2008). The persistence of the shock processes, except for the monetary policy shock, follows Beta distributions with mean 0.5 and standard deviation 0.2 (Smets and Wouters, 2003). Again, this choice reflects loose priors.

4 Estimation results

4.1 Parameter estimates

Table 3 summarizes the estimated posterior mean and 5 and 95 percentiles of the model parameters. The data is informative for the parameters as the estimated posterior distributions,

[22] This relatively large number ensures that the model remains in determinancy regions (Smets and Wouters, 2003).

[23] Up to a first order approximation around a zero net inflation steady state, the prior mean of 100 corresponds to an average Calvo price stickiness of approximately 0.75.

[24] Forni et al. (2009) use a Gamma prior with mean 0.5 and standard deviation 0.1 for these parameters. This range is covered by the prior distribution applied here.

including those of labor market and fiscal policy parameters, are moved away from the prior.[25] The estimation renders a high level of price stickiness with a posterior mean of $\Psi = 272.79$. This value corresponds to a Calvo parameter, i.e., a probability of not adjusting prices in a given quarter, of approximately 0.84 and an average price duration of approximately six quarters. Numbers in an equally high range have frequently been found in other studies, e.g., Sala et al. (2008), Thomas and Zanetti (2009), and Forni et al. (2009). Monetary policy reacts to inflation with a coefficient close to 1.7, while output reaction is modest with a posterior mean of 0.07. However, monetary policy reacts strongly to unemployment (-0.5). This result provides empirical foundations for the theoretical arguments for unemployment in Taylor rules(Faia et al., 2014). The monetary authority exerts a high degree of interest rate smoothing (ρ_i is approximately 0.95). Relative risk aversion remains close to the prior mean that is in line with findings in other studies.

The data is informative for labor market parameters. The posterior mean of the elasticity of the matching function with respect to unemployment, α, is 0.49.[26] The posterior mean of the workers' bargaining power is very high ($\gamma = 0.94$). In contrast, the posterior mean of the replacement rate is of moderate size (0.49), but larger than the prior and more concentrated.[27] The high bargaining power of workers generates strongly procyclical wages, i.e., wages respond forcefully to aggregate productivity, marginal costs of production and labor market tightness (see Eq. 16). A similar observation was made by Krause et al. (2008) in an estimation of a comparable DSGE model with search and matching frictions (although without fiscal rules, data on flow rates and endogenous separations). They also find a relatively strong bargaining power of workers and their posterior coverage region includes the estimates here. Flexible wages are well in line with the empirical observation of Haefke et al. (2013) that wages of new entrants in the US are highly flexible and move one to one with productivity. Hagedorn and Manovskii (2013) find that US wages do only depend on current conditions, not on past variables. Krause et al. (2008) argue that the labor market itself does not trigger persistence and volatility of the model under flexible wages. Instead, persistence and volatility originate from other model ingredients (e.g., strong nominal rigidities) and the exogenous shock processes. Endogenous job separations and a model fitted to flow rates instead of unemployment rates emphasize this effect.[28]

[25] Appendix C collects plots of the prior and posterior distributions and CUSUM plots that illustrate the convergence of the Markov chain.

[26] Although the posterior mean is close to the prior, the standard deviation is reduced substantially compared to the prior.

[27] At the posterior mean, the implied value of the vacancy posting costs κ is 0.016 and of the scaling parameter of the logistic distribution is 0.115.

[28] Note that the prior regions cover a model parameterization in the spirit of Hagedorn and Manovskii (2008) that would amplify the role of productivity shocks. However, the estimated posterior distributions do not show evidence in favor of this mechanism.

		Prior mean	Posterior Mean	Posterior 90% interval
Price setting, monetary policy, and preferences				
Price adjustment costs	Ψ	100.00	272.79	$[200.96; 345.92]$
Interest rate smoothing	ρ_i	0.75	0.9407	$[0.93; 0.95]$
Taylor rule response to inflation	ξ_π	1.70	1.7081	$[1.56; 1.87]$
Taylor rule response to output	ξ_y	0.13	0.0703	$[0.03; 0.11]$
Taylor rule response to unemployment	ξ_u	-0.20	-0.4893	$[-0.61; -0.38]$
Relative risk aversion	σ	2.00	2.0714	$[1.71; 2.43]$
Labor market				
Bargaining power	γ	0.50	0.9372	$[0.90; 0.98]$
Matching elasticity on unemployment	α	0.50	0.4944	$[0.44; 0.55]$
Replacement rate	rr	0.40	0.4968	$[0.42; 0.57]$
Fiscal policy				
Feedback of gvmt. debt on gvmt. spending	ψ_g	0.40	0.0233	$[0.01; 0.04]$
Feedback of gvmt. debt on consumption taxes	ψ_{τ^c}	0.40	0.0281	$[0.01; 0.04]$
Feedback of gvmt. debt on profit taxes	ψ_{τ^k}	0.40	0.1144	$[0.08; 0.15]$
Feedback of gvmt. debt on labor taxes	ψ_{τ^w}	0.40	0.0659	$[0.04; 0.09]$
Feedback of gvmt. debt on transfers	$\psi_{\tau^{ls}}$	0.40	2.3712	$[1.61; 3.10]$
Feedback of output on gvmt. spending	$\psi_{g,y}$	0.07	0.0181	$[0.00; 0.04]$
Feedback of output on consumption tax	$\psi_{\tau^c,y}$	0.05	0.0389	$[0.01; 0.07]$
Feedback of output on profit tax	$\psi_{\tau^k,y}$	1.00	0.3594	$[0.24; 0.48]$
Feedback of output on labor tax	$\psi_{\tau^w,y}$	0.50	0.3286	$[0.22; 0.44]$
Feedback of output on transfer	$\psi_{\tau^{ls},y}$	0.20	0.1409	$[0.03; 0.24]$
Co-movement of profit and labor tax	ζ_{kl}	0.25	0.2976	$[0.15; 0.44]$
Co-movement of profit and consumption tax	ζ_{kc}	0.25	0.2015	$[0.04; 0.37]$
Co-movement of labor and profit tax	ζ_{lk}	0.25	0.3714	$[0.26; 0.49]$
Co-movement of labor and consumption tax	ζ_{lc}	0.25	0.2080	$[0.05; 0.37]$
Co-movement of consumption and profit tax	ζ_{ck}	0.25	-0.0566	$[-0.12; 0.01]$
Co-movement of consumption and labor tax	ζ_{cl}	0.25	0.0477	$[-0.04; 0.13]$

Table 3: Posterior distributions of the estimated model parameters. The posterior is explored using the random-walk metropolis hastings algorithm with $500,000$ draws. I discard the first $250,000$ draws. The average acceptance rate is 0.35. The log marginal data density is computed using the modified harmonic mean estimator.

Nevertheless, as discussed below, the labor market influences the transmission of fiscal and non-fiscal shocks.

The posterior distributions of the fiscal rule parameters are different from zero. Spending, transfers and distortionary taxation respond to the level of debt. Government spending reacts to debt even though the feedback is relatively small with $\psi_g = 0.02$. This value is smaller than the estimate of Leeper et al. (2010), but close to the value set by Corsetti et al. (2012). According to the posterior means, transfers show the strongest reaction to current debt levels (ψ_{ls}); labor and consumption taxes the smallest. This ranking corresponds to the findings of Leeper et al. (2010).[29]

Posterior intervals of the parameters capturing automatic fiscal responses to output are also different from zero. At the posterior mean, profit taxes show a highly procyclical movement, closely followed by labor taxes. Transfers are strongly countercyclical. In contrast, the countercyclical reaction of government spending is small ($\psi_{g,y} = 0.018$). Shocks to capital and labor tax rates exhibit effects on both tax rates jointly (the corresponding ζ-coefficients are positive and different from zero). Movements in consumption taxes are not correlated with movements in other tax rates. Overall, the estimates of fiscal rule parameters are approximately in line with the results of Leeper et al. (2010). However, as discussed later, in the model with nominal rigidities and a frictional labor market, these rules imply different effects of fiscal policy.

Turning to the shock processes, posterior estimates of autocorrelation and shock size vary considerably across the different shocks (see Table 4). The process of preference shocks has the highest autocorrelation (approximately 0.9), followed closely by the autocorrelation of aggregate productivity and government spending. Likewise, shocks to tax rates exhibit strong autocorrelation (between 0.7 and 0.9). Shocks to lump-sum transfers and matching efficiency are less persistent (approximately 0.5). The price mark-up shock is effectively white noise. The price mark-up shock and the transfer shock have the largest standard deviations.[30] However, given that the absolute shock size is hard to interpret, the relative importance of the different structural shocks is discussed below in the context of a structural variance decomposition.

4.2 Model fit and properties

In order to check whether the estimated model fits the data sufficiently well, I compare the moments (auto- and cross-covariances at different leads and lags) of the data and of the estimated model (see Figure 13 in Appendix C for a visual representation of the moment comparison). The estimated model captures most of the covariances in US data fairly well (given that the

[29]Leeper et al. (2010) discuss that the strong reaction of transfers is partly model specific as transfers are non-distortionary, in contrast to taxes. I perform a robustness check where the response of lump-sum transfers to debt is fixed at zero. Results are discussed below.

[30]The relatively large standard deviation of the price mark-up shock is also found by Thomas and Zanetti (2009). Given that their model does not feature capital and investment adjustment costs, just as my model, the missing disturbances from the capital side possibly explain this finding. However, as revealed by the variance decomposition in the next section, mark-up shocks only drive inflation dynamics. This shock is of minor relevance for the labor market and fiscal policy. Thomas and Zanetti (2009) estimate a very large standard deviation of the shock to government spending. In my estimation, the data on government spending naturally restricts the size of the standard deviation of this shock.

		Prior mean	Posterior Mean	Posterior 90% interval
Autoregressive parameters				
Productivity	ρ_a	0.50	0.8585	$[0.83; 0.89]$
Government spending	ρ_g	0.50	0.8704	$[0.84; 0.91]$
Matching efficiency	ρ_μ	0.50	0.6067	$[0.51; 0.70]$
Price mark-up	ρ_φ	0.50	0.0359	$[0.01; 0.06]$
Preferences	ρ_d	0.50	0.9122	$[0.89; 0.93]$
Consumption taxes	ρ_{τ^c}	0.50	0.9053	$[0.88; 0.94]$
Labor taxes	ρ_{τ^w}	0.50	0.6987	$[0.64; 0.76]$
Profit taxes	ρ_{τ^k}	0.50	0.7544	$[0.70; 0.81]$
Transfers	$\rho_{\tau^{ls}}$	0.50	0.4619	$[0.39; 0.54]$
Standard deviations				
Monetary policy	σ_m	0.01	0.0024	$[0.00; 0.00]$
Productivity	σ_a	0.01	0.0056	$[0.01; 0.01]$
Government spending	σ_g	0.01	0.0073	$[0.01; 0.01]$
Matching efficiency	σ_μ	0.01	0.0209	$[0.02; 0.02]$
Price mark-up	σ_φ	0.01	0.2784	$[0.20; 0.36]$
Preferences	σ_d	0.01	0.0511	$[0.04; 0.06]$
Consumption taxes	σ_{τ^c}	0.01	0.0092	$[0.01; 0.01]$
Profit taxes	σ_{τ^k}	0.01	0.0197	$[0.02; 0.02]$
Labor taxes	σ_{τ^w}	0.01	0.0165	$[0.01; 0.02]$
Transfers	$\sigma_{\tau^{ls}}$	0.01	0.2376	$[0.17; 0.30]$
log marginal data density			$-3,306.95$	

Table 4: Posterior distributions of the shock processes. The posterior is explored using the random-walk metropolis hastings algorithm with $500,000$ draws. I discard the first $250,000$ draws. The average acceptance rate is 0.35. The log marginal data density is computed using the modified harmonic mean estimator.

baseline model does not embed typical features to increase model fit such as habit persistence, real wage rigidities, capital adjustment costs or further frictions, e.g., financial frictions).

Figure 1 confirms the satisfactory model fit. The one-step ahead Kalman forecast of the estimated model matches the data series including the flow rates.[31] Figure 2 compares the one-step ahead Kalman forecast of the unemployment rate of the estimated model and the true dynamics of the unemployment rate in the US economy. Even though the unemployment rate is not used as an observable variable in the estimation, the model replicates the true unemployment dynamics closely. However, the one-step forecast of the unemployment series is only half

[31]The one-period ahead forecast of inflation is too volatile in the model compared to the data as inflation is purely foreward looking in this model. Given that this paper does not focus on monetary policy and inflation, I do not allow for indexation to last period's inflation as introduced in estimated medium scale DSGE models (e.g., Smets and Wouters, 2007).

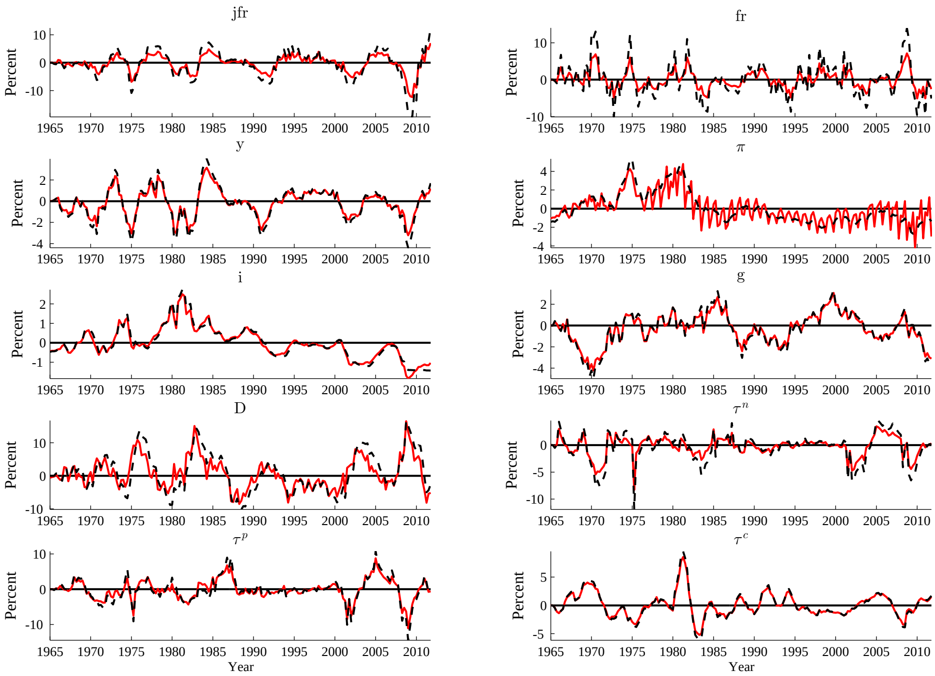

Figure 1: Comparison of US data (black dashed line) versus one-period ahead forecasts of observables of the estimated model (red solid lines). The plot shows deviations from steady state/trend. The one-period ahead forecast is obtained by Kalman filtering the state space representation of the estimated model at the posterior mean.

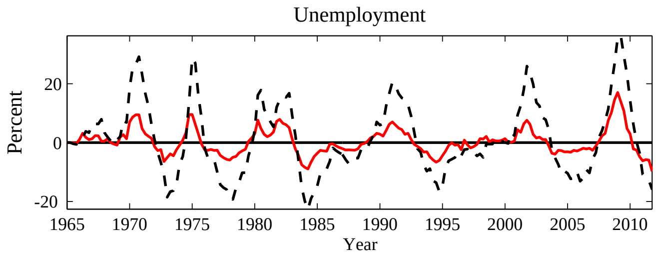

Figure 2: Comparison of unemployment in US (black dashed line) versus one-period ahead forecasts of unemployment of the estimated model (red solid lines). The plot shows deviations from an steady state/trend. The one-period ahead forecast is obtained by Kalman filtering the state space representation of the estimated model at the posterior mean.

as volatile as in the data. Unemployment is, nevertheless, still approximately four times as volatile as GDP. This finding illustrates that the model is not subject to the Shimer (2005) criticism. Standard search and matching models predict that unemployment is less volatile than productivity. There are two reasons for this difference. First, the model features an endogenous separation margin. Second, model dynamics are triggered by several shocks in addition to productivity shocks. Measurement error potentially explains the remaining discrepancy. The model assumes that unemployment is solely driven by job-finding and separation rates (from employment to unemployment). In reality, unemployment further responds to changes in labor market participation.

The estimated structural model allows to assess the role of each structural shock for the data dynamics. Table 5 illustrates the conditional and unconditional cross-correlations in the data and in artificial data simulated from the estimated model. In line with the discussion above, the estimated model perturbed by all structural shocks replicates the data correlations. The conditional correlations highlight the role of supply versus demand side disturbances. In the data, the correlation of GDP and interest rates is negative, but close to zero (-0.02). Productivity shocks generate a strong negative correlation of GDP and interest rates (-0.98). Preference shocks induce a positive correlation (0.40).[32] For this reason, a combination of productivity and preference shocks is a necessary model feature to explain aggregate data dynamics.

Preference shocks (and demand shocks in general) generate a strong correlation (close to one) of GDP and labor market flow rates. Given productivity stays constant, demand side disturbances necessarily amplify towards the labor market as production can then only rise if employment increases. Consequently, there is no Shimer (2005) puzzle in light of demand side disturbances. In contrast, in response to a positive productivity shock, production rises at

[32]Fiscal policy shocks also imply a positive correlation of GDP and interest rates. However, fiscal shocks are restricted by the data on the observable fiscal instruments.

least partly due to productivity gains. As a result, the corresponding correlation of GDP and labor market flows is far below one. In fact, in the estimated model, employment falls after a positive productivity shock.[33] This result is well in line with the prediction of standard New Keynesian models and the SVAR result by Galí (1999) on hours worked. Similarly, Balleer (2012) documents that job-finding rates show a negative, while separation rates show a positive response to productivity shocks in a SVAR similar to Galí (1999).

	GDP, job-finding rate	GDP, separation rate	GDP, interest rate	GDP, inflation
Data	0.83	-0.51	-0.02	-0.18
All shocks	0.37 [0.14; 0.57]	-0.31 [-0.52; -0.06]	-0.23 [-0.53; 0.12]	-0.23 [-0.48; 0.00]
Productivity shocks	-0.40 [-0.48; -0.30]	0.40 [0.30; 0.48]	-0.98 [-0.99; -0.96]	-0.94 [-0.97; -0.89]
Preference shocks	0.98 [0.96; 0.98]	-0.98 [-0.98; -0.96]	0.40 [0.34; 0.48]	0.74 [0.63; 0.81]
Monetary policy shocks	0.98 [0.97; 0.98]	-0.98 [-0.98; -0.97]	-1.00 [-1.00; -1.00]	0.77 [0.70; 0.83]
Government spending shocks	0.97 [0.96; 0.98]	-0.97 [-0.98; -0.96]	0.35 [0.27; 0.41]	0.58 [0.33; 0.74]

Table 5: Conditional and unconditional correlations in the model and in US data. Data correlations are obtained from HP filtered data (1965Q1 to 2011Q4). Model correlations are obtained from simulated data for the observable variables (deviations from trend). I report the median and the 5 and 95 percentiles. Simulations are based on 500 draws from the posterior distribution and 100 simulated data samples each. Simulated data is of the same size as the US data (after discarding the first $1,000$ simulated periods). In order to compute conditional correlations, the model is simulated based on one structural shock only.

All in all, the estimation fits the model sufficiently close to the true data dynamics in the US. Consequently, the estimated model forms a valid framework to assess fiscal policy. However, the next section starts by discussing the importance of the underlying structural disturbances in explaining labor market variables, first.

[33]The sign of the employment response depends on the exact parameterization of the model, in particular, on monetary policy and the shock persistence. Intuitively, employment rises only if households' consumption demands rise by more than the output increase from productivity gains. Monopolistic competitors only increase production if profits rise. The response of profits depends on the demand elasticity as monopolistic competitors face a downward sloping demand curve.

4.3 Variance decomposition of labor market variables

The search and matching literature still disagrees about the sources of labor market fluctuations. Given that search and matching models stand in the tradition of RBC models, the literature has focused on productivity shocks. Recently, fueled by the discussion on the Shimer (2005) puzzle and the incorporation of search and matching frictions in New Keynesian models, demand shocks have been put forward. Thus far, the formal analysis of the driving forces of labor market dynamics is restricted to SVAR analyses (Ravn and Simonelli, 2007, Braun et al., 2009 and Balleer, 2012). This paper is the first to assess this question in an estimated DSGE model with search and matching frictions.[34] This approach is standard in the literature on the sources of business cycles (e.g., Smets and Wouters, 2007 and Justiniano et al., 2010), but not yet systematically applied to evaluate labor market dynamics. The structure of the model allows to not only identify generic demand shocks, but disentangles preference, monetary policy, government spending, transfer and tax shocks.

Table 6 illustrates the conditional forecast error variance decomposition of the estimated model. Productivity shocks explain only approximately 10 percent of the dynamics of the job-finding and the separation rate; approximately 15 percent of unemployment dynamics. Instead, demand shocks, such as preference shocks and monetary policy shocks, explain a large share. Preference shocks drive approximately 40 percent of US flow rates and up to 60 percent of the dynamics of the unemployment rate. This finding fits to the notion of Hall (1997).[35] Nevertheless, productivity shocks are important for GDP. They explain more than 60 percent of output fluctuations in the long run. Approximately 35 percent of the variation in US flow rates is triggered by matching shocks. However, matching shocks do not explain movements in unemployment. The reason is that a temporarily higher matching efficiency increases the job-finding rate, but, everything else equal, the effect is offset as firms separate more workers due to endogenous separations. Monetary policy shocks explain approximately 15 percent of labor market flow and up to 20 percent of unemployment fluctuations. In general, fiscal shocks are not important for labor market variables.[36]

[34] Krause et al. (2008) perform a variance decomposition of a structurally estimated DSGE model with labor market frictions. However, they do not analyze labor market flow rates.

[35] In fact, preference shocks are important for the dynamics of most of the variables in the system, e.g., for GDP (see the discussion above in the context of Table 5). As a result, one may interpret preference shocks more broadly as a short-cut for demand shifts that may, e.g., result from disturbances in financial markets, i.e., along the risk premium for households' bond returns (Christoffel et al., 2009).

[36] I do not discuss the variance decomposition of the non-labor market variables here. Results are in line with common intuition. The price mark-up shock explains inflation dynamics, in particular, in the short run (Del Negro and Schorfheide, 2006 make a similar observation). Transfer shocks are relatively important for debt dynamics. This finding reflects that the cyclical component of debt is relatively volatile in the data (compared to GDP).

Overall, these findings are consistent with evidence based on structural VARs, even though, they are based on a very different identification of structural disturbances. Balleer (2012) shows in a structural VAR based on long run restrictions that approximately 20 percent of US labor market dynamics can be attributed to productivity shocks. Ravn and Simonelli (2007) find that monetary policy and productivity shocks are equally important for labor market dynamics with a mixture of long run and short run restrictions. In a structural VAR identified by sign restrictions, Braun et al. (2009) find that demand and supply shocks are equally important for labor market dynamics.

Interestingly, these findings do not change under real wage rigidities. Wage rigidities are one way to generate amplification in labor market variables in response to productivity shocks (Hall, 2005 and Shimer, 2005). Additionally, several studies argue that real wage rigidities are a necessary feature to explain the data dynamics with large DSGE models (e.g., Gertler et al., 2008 or Sala et al., 2008). Here, I follow Krause and Lubik (2007) and assume that the current wage is a weighted average of the Nash bargained wage and last period's average wage. Then,

$$w_t(\varepsilon) = (1-\chi)\Big[\gamma\Big(a_t mc_t - \varepsilon + E_t\Lambda_{t,t+1}\frac{\kappa}{q(\theta_{t+1})}\Big[\frac{1-\tau^p_{t+1}}{1-\tau^p_t} - (1-\eta_{t+1})\frac{1-\tau^n_{t+1}}{1-\tau^n_t}\Big] - E_t\Lambda_{t,t+1}(1-\phi_{t+1})(1-\eta_{t+1})\frac{1-\tau^n_{t+1}}{1-\tau^n_t}\frac{f}{1-\tau^p_{t+1}}\Big) + (1-\gamma)\frac{b}{1-\tau^n_t}\Big] + \chi w_{t-1}. \tag{27}$$

The weight on last period's wage is denoted by χ. I repeat the above estimation, but allow for explicit wage rigidities. The posterior mean of the wage rigidity parameter χ is relatively small.[37] The data prefer the specification where additional shocks, i.e., demand shocks, drive the dynamics of labor market variables to an enhanced role of productivity shocks from real wage rigidities. This finding corresponds to the empirical evidence of (Haefke et al., 2013) and the theoretical arguments of Krause and Lubik (2007) and Monacelli et al. (2010) who dismiss the relevance of real wage rigidities for inflation dynamics and the effects of fiscal stimulus, respectively. My findings confirm these results based on an estimated model. The estimated model suggests that amplification of productivity shocks as advanced by Shimer (2005) is not necessary if demand side disturbances explain aggregate fluctuations.

According to the variance decomposition, fiscal shocks are not important for aggregate dynamics on average. A similar result, although in a different model, is obtained by Leeper et al. (2010). However, this result does not necessarily mean that a one time shock (e.g., in times of crisis) may not have substantial effects on output or unemployment. For this reason, the next section assesses the effects of fiscal policy and the transmission towards the labor market in

[37] To be precise, the posterior mean of χ is 0.191. Accordingly, the variance decomposition does not change much compared to the numbers reported above. I set a Beta prior for χ with mean 0.5 and standard deviation 0.1.

more detail.

5 The effects of policy intervention

5.1 Multipliers of discretionary fiscal policy intervention

As common in the literature, I follow Mountford and Uhlig (2009) and analyze present value fiscal multipliers. The present value multiplier of government spending for output at horizon k is defined as

$$\text{Present value multiplier}(k) = \frac{E_t \sum_{j=0}^{k} \beta^j (y_t - y)}{E_t \sum_{j=0}^{k} \beta^j (g_t - g)}. \tag{28}$$

Tax multipliers are computed equally by replacing the absolute deviation of government spending with the absolute deviation of tax revenue from steady state. This approach expresses multipliers relative to the fiscal costs. I also evaluate unemployment multipliers as in Monacelli et al. (2010). That implies a replacement of the nominator with the deviation of unemployment from steady state (measured in percentage points) and a replacement of the denominator with the percentage point deviation of each fiscal instrument from steady state (measured in percent of steady state GDP). For easier comparison, I report multipliers for expansionary fiscal policy, i.e., increases in expenditures and cuts in taxes.[38]

Table 7 summarizes the estimated fiscal multipliers. Thanks to the Bayesian setting, the computation of the posterior distribution of fiscal multipliers is straightforward by sampling from the posterior distributions of the parameters. The first rows of Table 7 represent the baseline scenario where all fiscal instruments follow fiscal rules. Several observations stand out. On impact, each fiscal instrument has positive output multipliers. However, the size of the multipliers varies depending on the fiscal instrument. Moreover, unemployment multipliers behave as output multipliers, but with the opposite sign. Output and unemployment show a negative correlation in response to all fiscal instruments. Finally, multipliers are smaller than one as consumption is crowded out by the government intervention. In the following, I discuss the effects of each fiscal instrument in turn.

Government spending Output increases in response to expansionary government spending. The impact output multiplier is 0.32 (-0.37 for unemployment). Figure 3 illustrates the responses of several key model variables to an increase in government spending. In the following

[38]For the computation of tax revenue, I use steady state values of the corresponding tax base. I abstain from discussing multipliers of changes in the profit tax. As described before, the profit tax is a tax on firms' profits due to market frictions, and not on firms' capital stock. It should rather be considered as a proxy for movements along this margin that is not rich enough for policy evaluation.

	Productivity shock		Monetary shock		Spending shock		Mark-up shock		Preference shock		Matching shock		Transfer shock		Tax shocks	
Horizon	Mean	90% interval	Mean	90% interval	Mean	90% interval	Mean	90% interval	Mean	90% interval	Mean	90% interval	Mean	90% interval	Mean	90% interval
Variance decomposition of the job-finding rate																
1	0.10	[0.08; 0.12]	0.14	[0.11; 0.18]	0.01	[0.00; 0.01]	0.02	[0.01; 0.03]	0.44	[0.36; 0.53]	0.30	[0.22; 0.38]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
5	0.08	[0.06; 0.10]	0.13	[0.10; 0.17]	0.00	[0.00; 0.01]	0.02	[0.01; 0.03]	0.40	[0.31; 0.49]	0.37	[0.26; 0.47]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
20	0.08	[0.06; 0.10]	0.13	[0.10; 0.17]	0.00	[0.00; 0.01]	0.02	[0.01; 0.03]	0.39	[0.31; 0.49]	0.37	[0.25; 0.47]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
Variance decomposition of the firing rate																
1	0.09	[0.07; 0.11]	0.14	[0.11; 0.17]	0.01	[0.00; 0.01]	0.02	[0.01; 0.03]	0.42	[0.35; 0.51]	0.32	[0.25; 0.39]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
5	0.08	[0.06; 0.10]	0.14	[0.11; 0.16]	0.00	[0.00; 0.01]	0.02	[0.01; 0.03]	0.41	[0.33; 0.48]	0.35	[0.28; 0.41]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
20	0.08	[0.07; 0.10]	0.14	[0.11; 0.16]	0.01	[0.00; 0.01]	0.02	[0.01; 0.03]	0.41	[0.33; 0.48]	0.35	[0.28; 0.41]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
Variance decomposition of unemployment																
1	0.14	[0.10; 0.17]	0.20	[0.15; 0.24]	0.01	[0.01; 0.01]	0.02	[0.01; 0.04]	0.62	[0.55; 0.69]	0.01	[0.00; 0.01]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
5	0.12	[0.09; 0.15]	0.21	[0.17; 0.26]	0.01	[0.00; 0.01]	0.03	[0.01; 0.04]	0.63	[0.57; 0.70]	0.01	[0.00; 0.01]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
20	0.12	[0.09; 0.15]	0.21	[0.17; 0.26]	0.01	[0.00; 0.01]	0.03	[0.01; 0.04]	0.62	[0.55; 0.68]	0.01	[0.00; 0.01]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
Variance decomposition of GDP																
1	0.30	[0.24; 0.36]	0.16	[0.12; 0.19]	0.01	[0.00; 0.01]	0.02	[0.01; 0.03]	0.51	[0.44; 0.60]	0.00	[0.00; 0.01]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
5	0.53	[0.46; 0.60]	0.11	[0.09; 0.14]	0.00	[0.00; 0.01]	0.01	[0.00; 0.02]	0.33	[0.26; 0.40]	0.00	[0.00; 0.01]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
20	0.63	[0.55; 0.72]	0.09	[0.07; 0.11]	0.00	[0.00; 0.00]	0.01	[0.00; 0.02]	0.26	[0.18; 0.32]	0.00	[0.00; 0.01]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
Variance decomposition of inflation																
1	0.02	[0.01; 0.03]	0.01	[0.00; 0.01]	0.00	[0.00; 0.00]	0.96	[0.94; 0.97]	0.01	[0.01; 0.02]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
5	0.10	[0.05; 0.15]	0.02	[0.01; 0.03]	0.00	[0.00; 0.00]	0.84	[0.77; 0.90]	0.04	[0.01; 0.06]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.01	[0.01; 0.01]
20	0.12	[0.05; 0.20]	0.02	[0.01; 0.03]	0.00	[0.00; 0.00]	0.81	[0.72; 0.89]	0.04	[0.02; 0.07]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.01	[0.01; 0.01]
Variance decomposition of interest rates																
1	0.08	[0.07; 0.09]	0.54	[0.44; 0.65]	0.00	[0.00; 0.01]	0.07	[0.03; 0.11]	0.30	[0.21; 0.39]	0.00	[0.00; 0.01]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
5	0.14	[0.12; 0.17]	0.16	[0.11; 0.21]	0.01	[0.01; 0.01]	0.02	[0.01; 0.03]	0.66	[0.59; 0.73]	0.00	[0.00; 0.01]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
20	0.12	[0.08; 0.15]	0.07	[0.05; 0.09]	0.01	[0.00; 0.01]	0.01	[0.00; 0.02]	0.80	[0.74; 0.84]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
Variance decomposition of government spending																
1	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	1.00	[1.00; 1.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
5	0.00	[0.00; 0.01]	0.00	[0.00; 0.01]	0.93	[0.87; 0.99]	0.00	[0.00; 0.00]	0.01	[0.00; 0.01]	0.00	[0.00; 0.00]	0.03	[0.00; 0.06]	0.02	[0.02; 0.02]
20	0.04	[0.00; 0.08]	0.01	[0.00; 0.02]	0.86	[0.75; 0.99]	0.00	[0.00; 0.00]	0.01	[0.00; 0.02]	0.00	[0.00; 0.00]	0.04	[0.00; 0.07]	0.03	[0.03; 0.03]
Variance decomposition of D																
1	0.01	[0.01; 0.02]	0.03	[0.01; 0.06]	0.02	[0.01; 0.02]	0.05	[0.02; 0.07]	0.10	[0.03; 0.17]	0.00	[0.00; 0.00]	0.59	[0.45; 0.73]	0.20	[0.20; 0.20]
5	0.12	[0.10; 0.15]	0.08	[0.04; 0.11]	0.04	[0.03; 0.05]	0.02	[0.01; 0.03]	0.10	[0.03; 0.16]	0.00	[0.00; 0.00]	0.41	[0.28; 0.53]	0.23	[0.23; 0.23]
20	0.18	[0.13; 0.23]	0.07	[0.04; 0.10]	0.04	[0.03; 0.05]	0.02	[0.01; 0.03]	0.12	[0.04; 0.17]	0.00	[0.00; 0.00]	0.37	[0.25; 0.49]	0.20	[0.20; 0.20]

Table 6: Posterior forecast error variance decomposition for the US. The forecast horizon is measured in quarters.

	Spending multipliers		*Transfer multipliers*		*Labor tax multipliers*		*Consumption tax multipliers*	
Horizon	GDP	Unemployment	GDP	Unemployment	GDP	Unemployment	GDP	Unemployment
	All instruments adjust (-3,309.54)							
1	0.323 [0.27; 0.41]	-0.371 [-0.45; -0.31]	0.021 [0.01; 0.03]	-0.023 [-0.04; -0.01]	0.008 [-0.00; 0.02]	-0.010 [-0.03; 0.00]	0.163 [0.13; 0.20]	-0.183 [-0.23; -0.15]
5	0.188 [0.15; 0.25]	-0.198 [-0.26; -0.16]	-0.036 [0.25; -0.01]	0.041 [0.01; 0.19]	0.009 [0.00; 0.02]	-0.009 [-0.02; -0.00]	0.083 [0.07; 0.11]	-0.088 [-0.12; -0.07]
20	0.067 [0.05; 0.10]	-0.071 [-0.10; -0.05]	-0.029 [-0.04; -0.02]	0.030 [0.02; 0.04]	0.016 [0.01; 0.03]	-0.017 [-0.03; -0.01]	0.017 [0.01; 0.03]	-0.018 [-0.03; -0.01]
	Only transfers adjust, no fiscal rules (-3,328.63)							
1	0.280 [0.21; 0.34]	-0.326 [-0.40; -0.25]	0	0	-0.009 [-0.02; -0.00]	0.010 [0.00; 0.02]	0.102 [0.08; 0.13]	-0.121 [-0.16; -0.09]
5	0.165 [0.12; 0.21]	-0.178 [-0.23; -0.13]	0	0	0.008 [0.00; 0.01]	-0.009 [-0.01; -0.00]	0.060 [0.04; 0.08]	-0.065 [-0.09; -0.05]
20	0.074 [0.05; 0.10]	-0.079 [-0.10; -0.06]	0	0	0.017 [0.01; 0.03]	-0.019 [-0.03; -0.01]	0.027 [0.02; 0.04]	-0.029 [-0.04; -0.02]
	Transfers do not adjust (-3,391.13)							
1	0.407 [0.35; 0.46]	-0.494 [-0.57; -0.43]	0.037 [0.03; 0.04]	-0.045 [-0.05; -0.04]	0.052 [0.04; 0.06]	-0.063 [-0.07; -0.05]	0.305 [0.25; 0.37]	-0.371 [-0.44; -0.30]
5	0.237 [0.19; 0.29]	-0.262 [-0.31; -0.21]	-0.016 [-0.03; -0.01]	0.019 [0.01; 0.03]	0.029 [0.02; 0.04]	-0.030 [-0.04; -0.02]	0.134 [0.11; 0.16]	-0.148 [-0.17; -0.12]
20	0.085 [0.06; 0.11]	-0.094 [-0.13; -0.07]	-0.019 [-0.03; -0.01]	0.021 [0.01; 0.03]	-0.003 [-0.01; 0.01]	0.003 [-0.01; 0.02]	0.008 [-0.00; 0.02]	-0.009 [-0.02; 0.00]
	Only government spending adjusts (-3,578.87)							
1	0.444 [0.39; 0.50]	-0.558 [-0.66; -0.48]	0.051 [0.04; 0.06]	-0.065 [-0.08; -0.06]	0.062 [0.05; 0.07]	-0.078 [-0.09; -0.07]	0.269 [0.22; 0.30]	-0.340 [-0.38; -0.29]
5	0.341 [0.29; 0.41]	-0.360 [-0.43; -0.30]	0.023 [0.02; 0.03]	-0.024 [-0.03; -0.02]	0.050 [0.04; 0.06]	-0.056 [-0.07; -0.05]	0.162 [0.13; 0.19]	-0.187 [-0.22; -0.15]
20	0.348 [0.29; 0.41]	-0.193 [-0.24; -0.15]	-0.015 [-0.03; -0.01]	0.017 [0.01; 0.03]	0.008 [-0.01; 0.02]	-0.009 [-0.02; 0.01]	0.047 [0.04; 0.06]	-0.055 [-0.07; -0.04]

Table 7: Fiscal multipliers for the US. Numbers show the posterior median and the 5 and 95 percent posterior intervals. Multipliers are present value multipliers. Multipliers are reported for an increase in spending and transfers and for cuts in taxes. Numbers in paranthesis indicate the log marginal data density of each specification (based on the modified harmonic mean estimator).

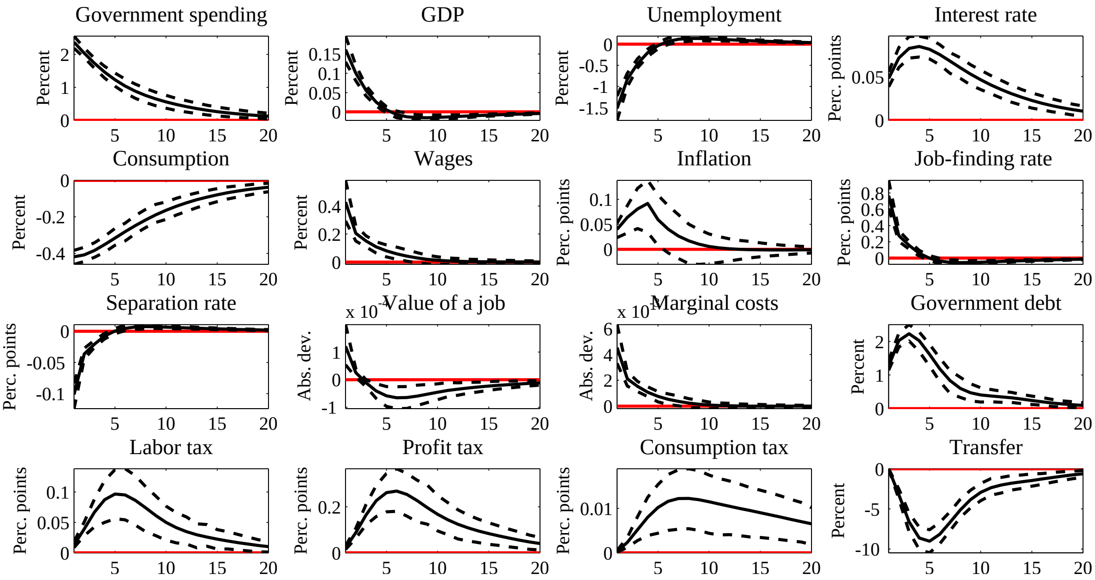

Figure 3: Estimated impulse responses to an increase in government spending (0.5 percent of GDP) in the US. The solid line shows the impulse responses at the posterior mean; the dashed lines at the 5 percent and 95 percent posterior intervals. The impulse horizon is measured in quarters.

figures, fiscal interventions are normalized to an increase in spending or a cut in taxes of 0.5 percent of steady state GDP. Solid lines show the responses at the posterior mean, dashed lines capture the 5 and 95 percent posterior intervals. In line with the multipliers, GDP increases and unemployment falls in response to a discretionary spending upsurge. The intuition for the positive effects is the following. As typical in a New Keynesian model, rising government demand drives up the marginal costs of production, but given that prices are sticky, inflation responds only gradually. Profit maximizing monopolistic firms react by producing more consumption goods and demanding more intermediate goods. In order to increase employment to meet this demand, intermediate goods producers post more vacancies which increases the job-finding rate and fire fewer workers. Hiring and retaining additional workers drives up the marginal costs of production. The unemployment rate falls, while wages rise. According to the Taylor rule, the monetary authority rises interest rates in response to the inflationary pressure and the deviation of output and unemployment from steady state. Higher interest rates crowd out private consumption. The estimated Taylor rule features strong interest rate smoothing. As a result, interest rates rise only moderately and crowding out is dampened.

So far, none of the responses is surprising. However, due to the fiscal rules, the increase in government spending results in feedback effects on the other fiscal variables. The additional spending is financed by an increase in government debt on impact. The accumulated debt generates rising tax rates and lower spending in the future. Fiscal stabilization peaks around quarter five after the shock. Most of the fiscal adjustment is borne by lump-sum transfers. This finding reflects the large estimate of the fiscal rule parameter for transfers. In response to rising distortionary taxes and lower transfers, GDP falls below steady state approximately five quarters after the initial spending increase. Under nominal rigidities, a negative output gap depresses inflation and, consequently, interest rates. Accordingly, households expected long term real interest rates fall already on impact. As suggested by Corsetti et al. (2012), lower long term interest rates dampen the induced impact decline in consumption compared to a scenario without fiscal rules. Nevertheless, the effects are smaller as argued by Corsetti et al. (2012). Spending reversals and consumption crowding in do not arise as government spending does not fall below steady state given that fiscal consolidation is pursued mainly by adjusting alternative fiscal instruments instead of government spending only.

Transfers An increase in transfers has very small positive multipliers on impact (0.02 for output), and small negative multipliers in the medium and the long run. Lump-sum transfers are non-distortionary in this model. Without the presence of fiscal rules, changes in transfers would not have any effect on the economy (except for government debt), i.e, Ricardian equivalence would hold. Figure 4 shows the responses of the US economy to an increase in transfers. Higher transfers generate rising government debt. As a result, fiscal policy is contractionary in the future. Transfers react very fast. They fall below steady state already three quarters after the initial increase. Then, also GDP falls below steady state. Accordingly, the small impact increase of consumption results from (expected) future interest rates below steady state. This increase in demand generates very small positive output (and negative unemployment) effects as the value of a job increases. Nevertheless, the medium run and long run negative effects from contractionary fiscal policy that consolidates debt are so large that they quickly offset these small positive effects. Given that the increase in lump-sum transfers is financed to some extent by distortionary taxation, the cumulative long run effect is negative (-0.04 for output and 0.04 for unemployment five quarters after the initial expansionary transfer shock).

Labor tax cuts Multipliers of discretionary labor tax cuts turn out to be very small (see Table 7).[39] The impact multiplier is only 0.01. Unemployment falls, but multipliers are equally small. Figure 5 shows the corresponding impulse responses. The labor tax cut influences output and unemployment through wages. The labor tax cut depresses households' wage demands and wages as it increases the value of working relatively to non-working (after taxes, see Eq. 16). This indirect effect from the Nash wage bargaining differs from the outcome in a neoclassical labor market. Changes in the labor tax generate no direct effect on labor supply given that labor

[39] For discretionary tax policy, I consider changes in one tax rate at a time, i.e., the correlation among shocks to tax rates is set to zero.

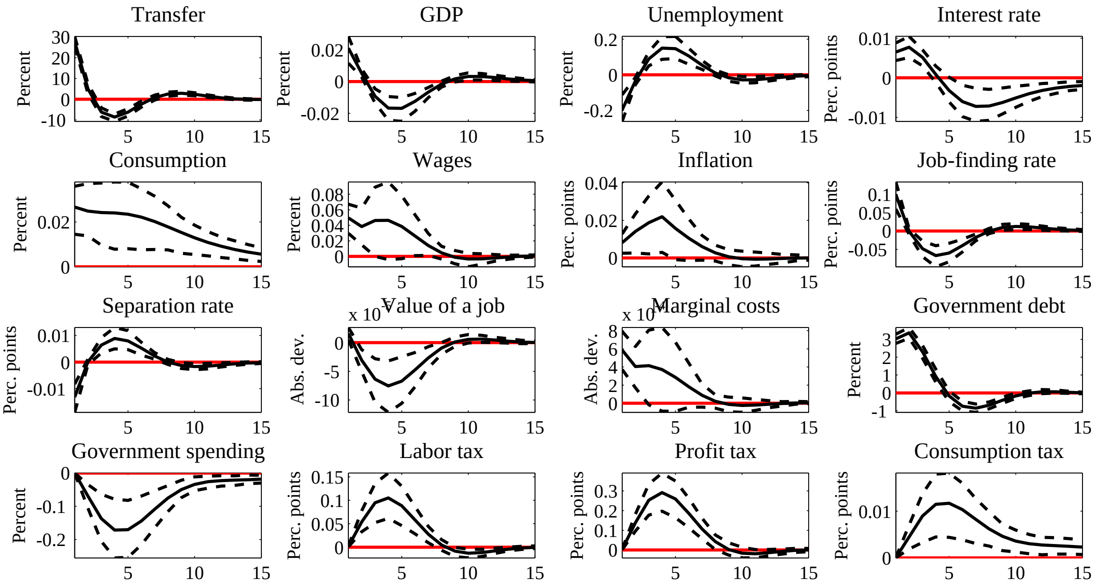

Figure 4: Estimated impulse responses to an increase in lump-sum transfers (0.5 percent of GDP) in the US. The solid line shows the impulse responses at the posterior mean; the dashed lines at the 5 percent and 95 percent posterior intervals. The impulse horizon is measured in quarters.

supply is exogenous due to the search and matching friction.[40] Lower wages diminish marginal costs of production and firms' hire more and fire less workers. GDP rises, unemployment falls. Simultaneously, inflation decreases with marginal costs of production. Consequently, the central bank lowers interest rates, which in turn stimulates consumption. However, the effects are tiny and short-lived. The main reason is that the effect of the labor tax cut on wages and marginal costs is relatively small. According to the estimated model, wages move almost one to one with the marginal costs of production. As a result, they hardly move if the outside option of the workers changes (as the estimated workers' bargaining power is close to one, see Eq. 16). Small wage cuts provides only small incentives for intermediate firms to increase employment and production (the value of a job increases only slightly). Likewise, the effect on inflation and interest rates is limited (given that Rotemberg price adjustment costs and interest rate smoothing are high). According to the estimated fiscal rules, the labor tax cut is followed by rising tax rates and reluctant spending in the future. As described in the case of government spending, this promotes consumption (but effects are small).

Consumption tax cuts Multipliers for a cut in consumption taxes are larger than those for labor taxes. A cut in consumption taxes has an impact output multiplier of 0.16. The cor-

[40] Labor taxes are 'less' distortionary is this setting compared to a model where they also distort the optimal labor-leisure decision of the household. Here, they increase wages (and decrease employment) relative to a model without labor taxes.

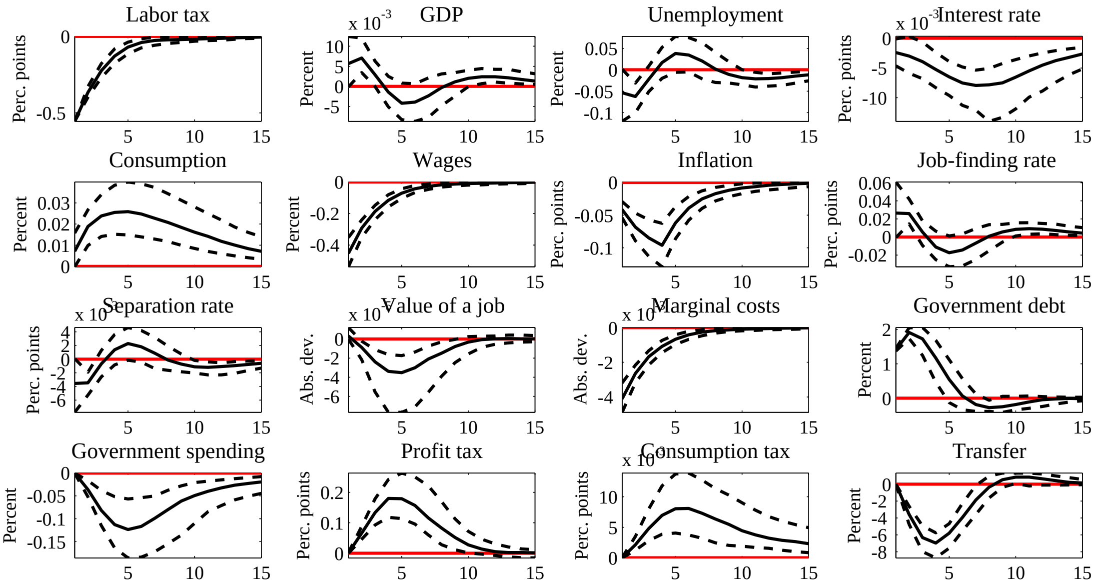

Figure 5: Estimated impulse responses to a cut in labor taxes (0.5 percent of GDP) in the US. The solid line shows the impulse responses at the posterior mean; the dashed lines at the 5 percent and 95 percent posterior intervals. The impulse horizon is measured in quarters.

responding unemployment multiplier is -0.18. Figure 6 illustrates the model responses to a cut in the consumption tax. Consumption becomes relatively cheaper and households consume more. Put differently, the marginal utility of consumption today increases relative to the marginal utility of consumption in the future (see Eq. 3). This increase in demand induces similar, although only about half as large, effects compared to an increase in government spending. The latter has stronger effects on aggregate variables as non of the additional spending is saved. Firms increase employment and GDP rises. Fiscal rules imply that spending, transfers and tax rates all adjust to rising debt levels (at peak approximately four quarters after the initial shock). This contractionary policy results in GDP slightly below steady state from quarter five after the shock onwards. Again, lower future inflation and interest rates compared to an economy without fiscal rules bolsters consumption already on impact (see Corsetti et al., 2012 in the context of government spending).

The results demonstrate that fiscal policy can be effective in terms of output and unemployment, but the effect depends strongly on the fiscal instrument applied. Expansionary discretionary changes in government spending and consumption taxes stimulate demand and work well. However, an increase in government spending is more effective than a consumption tax cut. The effects of changes in labor tax rates are tiny. If the government stimulates demand by higher lump-sum transfers, the long run negative effects due to fiscal rules quickly offset the

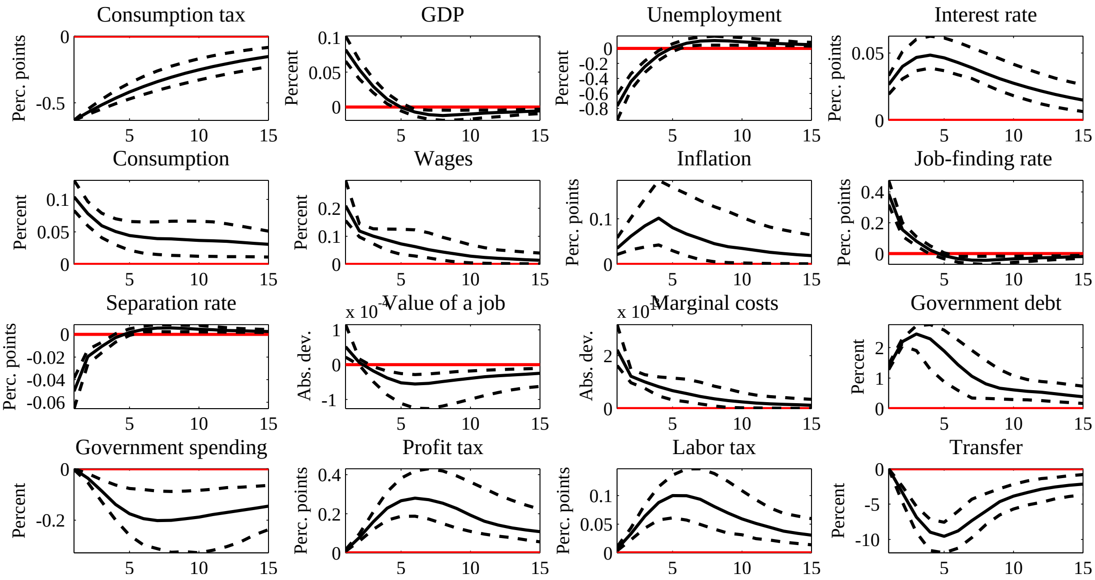

Figure 6: Estimated impulse responses to cut in consumption taxes (0.5 percent of GDP) in the US. The solid line shows the impulse responses at the posterior mean; the dashed lines at the 5 percent and 95 percent posterior intervals. The impulse horizon is measured in quarters.

small short run positive effects.

5.2 The influence of fiscal rules

This section analyzes the influence of fiscal rules on the multipliers in more detail. Table 7 (p. 28) summarizes the estimated fiscal multipliers for the US under alternative fiscal rules. I compare the baseline results where all fiscal instruments adjust to debt to three alternative specifications: one specification where lump-sum transfers do not adjust, one specification where only government spending adjusts to debt, and, finally, one specification where only lump-sum transfers adjust to debt.[41] The specification without an adjustment in transfers explores how results change if the only non-distortionary fiscal instrument is excluded from the fiscal rules. The specification where only government spending adjust is close to the study of Corsetti et al. (2012) and allows to analyze the role of spending reversals. The specification where only lump-sum transfers adjusts replicates the results if the existence of fiscal rules would have been ignored. Then tax rates and spending follow conventional AR(1) processes and I set the parameters capturing automatic stabilization and the co-movement in tax shocks to zero. In this specification, Ricardian equivalence holds.

[41]These specifications are estimated as described in Section 3. The only difference is that the respective fiscal adjustment parameters are fixed at zero.

Table 7 highlights the following findings. First, all alternative fiscal rule specifications have a lower (log) marginal data density compared to the baseline scenario where all fiscal instruments adjust to debt. Model fit deteriorates by restricting certain fiscal rule components to zero. The data clearly prefer the specification where all instruments adjust.[42] Second, multipliers are substantially smaller if fiscal policy does not follow fiscal rules. The consumption tax multiplier is approximately 40 percent smaller if fiscal rules are switched off. The government spending multiplier is reduced by 15 percent. This finding stresses that the relatively large multipliers for consumption tax cuts are to a large extent driven by the presence of fiscal rules.[43]

Third, the size of fiscal multipliers depends on the exact specification of the fiscal rules. Or put differently, multipliers differ depending on which fiscal instrument is used to adjust debt levels in the future. In general, present value multipliers are the larger, the more of the future debt adjustment is taken over by government spending. The reason for this finding is the Corsetti et al. (2012) effect as discussed above. Reduced future government spending depresses output, inflation and interest rates in the future. Lower future interest rates stimulate consumption and reduce consumption crowding out already at present as the long run real interest rate declines. This effect is the largest for government spending as changes in tax rates exhibit smaller effects on the economy and on interest rates.

In the specification where only government spending adjusts, and only in this specification, the model replicates the spending reversals as described by Corsetti et al. (2012). However, this specification is the least favored by the data. A spending reversal generates government spending below steady state some periods after the initial increase in spending to consolidate rising debt.[44] If tax rates or transfers are allowed to adjust to debt, spending does not react as strongly as to generate a reversal. This hypothetical scenario exhibits the largest fiscal multipliers. The impact output multiplier of government spending goes up to 0.44 (compared to 0.32 in the baseline). Nevertheless, according to the estimated rules, the effects are not so strong as to generate consumption crowding in as in Corsetti et al. (2012). Not only the effects of government spending are enhanced, but also the output multiplier of a cut in consumption taxes increases to 0.27 (compared to 0.16 in the baseline). The consumption tax multiplier increases by approximately

[42]This result corresponds to the findings in Leeper et al. (2010) in a different model. Compare, e.g., An and Schorfheide (2007) for an evaluation why the marginal data density is the right statistic to compare different models in this context.

[43]The impact multiplier of labor tax cuts turns negative if fiscal rules are excluded. This finding strongly depends on the parameterization. Here, inflation drops more than nominal interest rates (due to heavy interest rate smoothing). This increases the real interest rate and the stochastic discount factor falls on impact. The value of long run employment relationships depreciates which in turn depresses hiring and increases firing. The effects are, however, very small.

[44]Appendix D shows the estimated impulse responses in response to a government spending shock for this model specification.

two thirds. For comparison, the spending multiplier increases by approximately one third. This outcome again stresses the importance of fiscal rules for consumption taxes. Likewise, the effects of transfers and labor tax cuts are enhanced, but the effects are small.

Nevertheless, it is important to note that the short run benefit of enhanced multipliers if only government spending consolidates public debt is bought by stronger negative effects in the future. Even though the present value multipliers remain positive, GDP falls substantially more below steady state. The choice of the fiscal policy mix to consolidate debt trades off short run benefits versus medium run losses (in terms of output and unemployment).[45]

In sum, the different fiscal rule specifications provide evidence that consumption crowding out is reduced by expected lower government spending in the future as proposed by Corsetti et al. (2012). However, the estimation reveals that not only spending, but taxes and transfers also adjust. The size of fiscal multipliers depends on the fiscal policy mix used to consolidate rising debt levels and trades of future income losses versus short run gains. Multidimensional fiscal rules have strong effects on the effectiveness of fiscal policy.

5.3 Automatic stabilization from fiscal rules

The estimated fiscal rules provide a unique setting to not only analyze the effects of discretionary fiscal policy intervention (shocks to fiscal rules), but to also evaluate the extent of automatic stabilization from fiscal rules. It is important to define what automatic stabilization from fiscal rules refers to in this context. In the model, automatic stabilization consists of two distinct components. First, given that taxes are proportional to the respective tax base and aggregate unemployment benefits move if employment moves, the total government budget changes automatically in response to the business cycle. Second, rule-based changes in tax rates, spending and transfers stabilize if output falls below steady state due to fiscal rules. Tax rates may change automatically because of two effects: first, due to progressive tax rates and allowances that are defined in the tax code, and, second, due to active changes in the tax code that are implemented in a rule-based manner. The literature on automatic stabilizers disagrees about the relative importance of the different components of automatic stabilization (in't Veld et al., 2013). The estimated fiscal rules in this paper clarify the effects of rule-based changes in fiscal instruments, i.e., automatic stablization from fiscal rules.

The estimated structural model allows to create a counter factual situation if fiscal rules

[45] A normative analysis of this question would be an interesting extension. Thus far, the literature on optimal fiscal rules concentrated on the question whether policy adjustment should be temporary or permanent or whether counter cyclical policy enhances welfare. The optimal fiscal policy mix under the possibility of spending reversals has not yet been analyzed. Arseneau and Chugh (2012) find that labor market frictions matter for the optimal conduct of fiscal policy.

	Relative to estimated model	Relative to model with enhanced stabilization
Output	0.30	2.67
Unemployment	0.69	5.35

Table 8: Reduction of the standard deviation (in percent) of output and unemployment in the estimated US model in case of automatic stabilization from fiscal rules in taxes, transfers, and government spending. Output and unemployment are measured in percentage deviations from steady state. Enhanced stabilization implies that the parameters governing the stabilization in fiscal rules are multiplied by a factor of 10.

do not respond to the current output level.[46] This experiment captures a situation in which neither government spending, nor lump-sum transfers, nor tax rates respond automatically to the business cycle. In the following, I measure stabilization in terms of the reduction of the volatility of output and unemployment in the model with active automatic stabilization from fiscal rules compared to a model without this automatic policy component. The volatility in aggregate variables is driven by the full set of structural shocks. Table 8 summarizes the main results from the baseline estimated model.

The results suggest that, according to the estimated fiscal rules, automatic stabilization from fiscal rules is present, but not important for aggregate variables in the US. The standard deviation of output and unemployment is reduced by less than 1 percent by the automatic adjustment of spending, tax rates and transfers to output. In case the government increases the parameters in the fiscal rules triggering the response of tax rates, spending and transfers to output (the $\psi_{\cdot,y}$'s) by a factor of 10, automatic stabilization from fiscal rules would be more sizable. This scenario implies output stabilization of 2.7 percent and unemployment stabilization of 5.4 percent. Consequently, automatic stabilization from fiscal rules is possible, but has not been large in the US in the last 50 years. In this exercise, I examine the change in volatility. In contrast, Leeper et al. (2010) find in a complementary exercise that the long run effects of discretionary policy intervention change under a different automatic response of fiscal instruments to output. They argue that stronger short run stabilization, i.e., larger absolute $\psi_{\cdot,y}$'s, induce long run costs due to necessary future debt consolidation. This finding may explain why the overall effect on volatility is small if short run stabilization is offset by long run costs.

The identified extent of automatic stabilization is smaller than suggested by findings in empirical studies. Although, empirical estimates vary depending on the methodology applied, in't Veld et al. (2013) argue that estimates of automatic stabilization of the income tax system alone range between 8 and 20 percent for the US. However, numbers are only partly comparable as the empirical estimates refer to the total automatic stabilization, including stabilization as a

[46]This implies that the $\psi_{\cdot,y}$-coefficients in the fiscal rules are set to zero. All other parameters are set at the posterior mean of the baseline estimated model. This exercise does not affect the steady state of the model.

result of proportional taxation by itself. My results show that the additional stabilization from rule-based changes in tax rates, e.g., due to a progressive income tax system, are small. In turn, these findings suggest that the majority of the stabilization identified in empirical estimates arises from cyclical revenues. Cyclical revenues result from taxation moving one to one with the tax base. Balleer et al. (2014) show that policies directly aimed at the labor market, such as short-time work, may exhibit strong automatic stabilization, in particular, of unemployment.

5.4 Multipliers in a more rigid labor market

In order to better understand the effects of a frictional labor market on fiscal multipliers, I next examine an economy with different labor market institutions and, on average, lower labor market flow rates. The German economy is characterized by job-finding and separation rates that are approximately three times smaller than in the US, by positive firing costs and collective wage bargaining. To match these characteristics, the model is modified towards a collectively bargained wage (see Appendix E for details on the model and the estimation).

The most striking differences occur on the labor market. This result stresses the importance of an explicit modeling of the labor market. As discussed by Gartner et al. (2012), lower average flow rates in Germany are accompanied by higher volatility. In order to match this volatility, the estimation moves the model towards additional amplification of productivity shocks. Less cyclical wages imply that firms' profits respond more to changes in the surplus of a match and, as a result, firms have stronger incentives to adjust employment. In the estimated model, this feature is reflected by a relatively low bargaining power. Stüber (2013) demonstrates with German microeconomic data that German wages are cyclical, but less cyclical than suggested by studies for the US.[47] Productivity shocks explain up to 50 percent of the movements in output and labor market variables (see Table 13 in Appendix E). This finding is in line with SVAR evidence for Germany (e.g., Nordmeier and Weber, 2013). The different wage dynamics are not only due to the different bargaining game, but hold if I estimate the US model with collective bargaining. Fiscal rule parameters are on average larger in Germany compared to the US. The German economy responds faster to rising debt levels and adjusts less through lump-sum transfers.

These findings have important implications for the size of fiscal multipliers (see Table 14 in Appendix E). The stronger labor market friction generates larger multipliers of fiscal policy in Germany compared to the US. The impact output multiplier of government spending is 0.62 (-0.57 for unemployment). The impact multiplier of a cut in consumption taxes is 0.32 (-0.29

[47] Due to methodological differences, however, the German and US numbers might not be 100 percent comparable. Wage cyclicality is an active and growing area of research.

for unemployment). Multipliers of an increase in transfers and a cut in labor taxes are close to zero, as in the US. However, a cut in transfers has strong negative medium run and long run effects on output.

The intuition for this finding is the following: Given that wages respond less to market conditions, incentives for German firms remain high to increase employment and, consequently, production. Furthermore, the positive impact of fiscal rules is stronger as fiscal instruments adjust faster to rising debt levels. The central bank responds less as interest rate smoothing is strong which dampens consumption crowding out. However, simulations show that most of the increase in multipliers is driven by the different wage response and differences remain if fiscal rules are switched off. In sum, multipliers of discretionary fiscal policy intervention are larger in an, on average, more rigid, but also more volatile labor market. This finding stresses that labor market characteristics are highly relevant for the effects of fiscal policy.

5.5 Putting the results in perspective

A few comparable studies that analyze fiscal policy in the context of labor market frictions exist in the literature. However, non of these studies explores such detailed fiscal rules as I do, nor do they estimate their DSGE models. Monacelli et al. (2010) argue that a New Keynesian model with search and matching frictions and exogenous separations can only replicate sizable output and unemployment multipliers (i.e., 0.6 and larger) if one assumes a high replacement rate/value of non-work to work activities (approximately 0.9).[48] For conventional values, they find multipliers close to zero. In the Monacelli et al. (2010) model wages decrease in response to a government spending shock,[49] even though a complementary SVAR analysis demonstrates that wages rise. In contrast, the estimated model in this paper replicates well that wages increase after a government spending shock. Moreover, thanks to the endogenous separation margin and the presence of fiscal rules, spending multipliers are closer to sizable values.

Campolmi et al. (2011) allow for endogenous participation in a New Keynesian model augmented with search and matching frictions. They argue that output spending multipliers are small (around 0.2 with lump-sum financing and around 0.1 with distortionary financing). However, the model in Campolmi et al. (2011) has a substantially different representation of fiscal policy. Government spending is financed either by one hundred percent lump-sum taxes or by a fixed percentage of expenditures through labor taxes. This implies that fiscal rules do not influ-

[48]This approach has first been promoted by Hagedorn and Manovskii (2008) as a way to solve the Shimer (2005) puzzle.

[49]Monacelli et al. (2010) weigh the outside option of the workers by the marginal utility of consumption. As a result, if consumption is crowded out, the marginal utility of consumption increases. This feature in turn decreases the outside option of workers in the bargaining game.

ence future tax rates and spending, but current tax rates, and explains the different multipliers.[50]

Faia et al. (2013) analyze fiscal policy in a labor selection model instead of a search and matching model. They find a short run output multiplier of government spending of only 0.18 (in a European labor market without fiscal rules). Their long run multipliers are closer to my estimates for Germany with a value of 0.47. They also find that multipliers can be larger under fiscal rules and spending reversals. However, given that they do not estimate their model, fiscal rules are applied equally for spending and labor taxes. My results show that multipliers depend on the exact specification of fiscal rules and that spending reversals do not necessarily occur. Interestingly, Faia et al. (2013) also analyze the effects of alternative fiscal instruments in addition to government spending. They find relatively large multipliers for labor tax cuts (0.4 to 0.7). My results show that this is not necessarily the case under a parameterization of wage setting and inflation dynamics that is chosen by the data and under multi-dimensional fiscal rules.[51] In their working paper version, Faia et al. (2013) also evaluate the effects of changes in consumption taxes. They argue that those exhibit near zero multipliers under lump-sum financing. My results suggest that fiscal rules are of particular importance for the size of consumption tax multipliers. Even under lump-sum and debt financing, some small effects of consumption tax cuts arise. Strong interest rate smoothing of the central bank generates very moderate increases in interest rates in response to inflation. As a result, the positive effects of the tax cut on consumption are not dampened due to monetary policy intervention. This finding highlights the importance of modeling fiscal and monetary policy in a joint framework. Moreover, consumption tax cuts are relatively persistent according to the estimated model. Forni et al. (2009) find relatively strong multipliers for consumption tax cuts in an estimated model with rule-of-thumb households without labor market frictions.

Empirical evidence from structural VARs provides mixed results on the size of fiscal multipliers. Estimates vary largely depending on the method and identification applied. For the US, Hall (2010) concludes that most VAR studies find positive output multipliers of government spending between 0.5 and 1 (e.g., Fatás and Mihov, 2001, Blanchard and Perotti, 2002, and Mountford and Uhlig, 2009).[52] These studies typically do not explicitly focus on the la-

[50]Furthermore, their calibration is in parts far away from the posterior distributions obtained here. For instance, they set a very low price adjustment cost parameter.

[51]The difference is essentially driven by two effects. As explained above wages react less to labor tax cuts due to the high bargaining power. Furthermore, adjusting prices is relatively costly according to the estimated parameterization. Consequently, inflation falls less in response to the drop in marginal costs compared to an economy where price adjustment is less costly. For this reason, interest rates fall less which in turn depresses positive effects on consumption. Strong interest rate smoothing compounds this effect.

[52]There is evidence that spending multipliers can be much larger in recessions if the zero lower bound holds (compare, e.g., Auerbach and Gorodnichenko, 2012 for evidence based on regime-switching SVARs and Eggertsson, 2011 for theoretical considerations). I focus on fiscal multipliers under conventional business cycle movements.

bor market responses. One exception is Monacelli et al. (2010) who show that an increase in government spending (of 1 percent of GDP) stabilizes unemployment by 0.6 percentage points (at the peak).[53] Ravn and Simonelli (2007) find that unemployment decreases at maximum by 1.5 percent three years after an one percent spending shock. Mountford and Uhlig (2009) argue that tax multipliers can be very large, especially in the long run. However, estimates vary with the identification strategy. For example, Blanchard and Perotti (2002) find smaller tax than spending multipliers. Evidence on the direct effect of tax policy on unemployment is scarce.

For Germany, the empirical SVAR evidence on fiscal multipliers is even more diverse. In an overview, Roos (2007) finds that output multipliers for government spending are in general smaller than 0.6, while effects could even be negative; tax cuts tend to have small, but positive multipliers. Perotti (2005) identifies an impact spending multiplier just above one; impact tax multipliers are negative. Tenhofen et al. (2010) observe an impact spending output multiplier of 0.8. Breuer and Büttner (2010) find that the multiplier of government expenditures is 1.5, whereas they identify a tax multiplier below one. The only SVAR study analyzing labor markets and fiscal policy in Germany is Nordmeier and Weber (2013). They find an unemployment multiplier for spending of only 0.1.

My estimates are at the lower bound of the US range for output multipliers. In contrast, the estimated unemployment multiplier of -0.32 percentage points for an increase in government spending of one percentage point of GDP is more sizable compared to the findings in the literature. As discussed above, the multipliers derived here are in general larger for Germany. These numbers are in the mid range of the existing estimates summarized above. However, my results sound a cautionary note on the effects of tax cuts. According to my model estimates, tax multipliers are always smaller than spending multipliers and may be close to zero in the case of labor tax cuts. This finding challenges the results of Mountford and Uhlig (2009) for the US, but is in line with estimates for Germany (Roos, 2007).

According to the estimated model, government spending crowds out consumption even in the presence of fiscal rules. The reaction of consumption has been studied extensively in the empirical SVAR literature on fiscal policy. Depending on the identification of the SVAR, most studies conclude that consumption either rises or shows no significant reaction to government spending shocks. This finding is at odds with predictions of models based on optimizing agents, such as the one applied here. Multi-dimensional fiscal rules lead to small crowding in effects. However, these are not large enough to offset the total crowding out of consumption. Augmenting the model with non-optimizing agents would be an interesting extension that may result in on average larger multipliers (Galí et al., 2007, Forni et al., 2009).

[53] This estimate is probably in the upper range as they report a corresponding output multiplier of 1.2.

6 Conclusions

This paper provides evidence on the effects of fiscal policy in a model featuring labor market frictions, distortionary taxes and rich fiscal rules. The model is estimated using detailed data on labor market flows, tax rates, government spending and debt. The results demonstrate that a discretionary upsurge in government spending is most effective in terms of increasing output and reducing unemployment. Likewise, consumption tax cuts are effective, but multipliers are approximately half as large as for government spending. In contrast, the explicit acknowledgement of the labor market friction highlights that labor tax cuts are incapable of stabilizing output and unemployment. The results further illustrate that fiscal policy is more effective in a more rigid labor market if wages respond less to market conditions. The dynamics of wages and the modeling of the labor market is decisive for the examination of fiscal policy.

The analysis emphasizes that fiscal rules matter for the effects of fiscal policy. Expectations of future tax increases and spending restraint affect households' current consumption decisions and reduce consumption crowding out. However, the estimated rules reveal that the effects are smaller than proposed by Corsetti et al. (2012) since governments use the full set of fiscal instruments to adjust to debt and not only spending restraint. In the context of fiscal consolidation, fiscal rules generate larger short run output losses of spending cuts and tax increases if fiscal consolidation is not credible, i.e., if households expect that consolidation will be followed by rising expenditures in the future. Stabilization due to the automatic adjustment of fiscal instruments to the business cycle is small.

The estimated model shows that productivity shocks explain only approximately 10 percent of labor market flow dynamics in the US. The majority of labor market dynamics originates from demand side disturbances. This finding complements evidence from SVARs and sounds a cautionary note on considering productivity shocks as the sole driving force of labor market dynamics.

The results prove that multi-dimensional fiscal rules and labor market frictions are relevant features when modeling fiscal policy. Neglecting fiscal rules leads to an underestimation of the true effects of fiscal policy intervention. In an economic downturn, discretionary fiscal policy generates the largest stimulus if only government spending consolidates public debt in the future. However, these short run gains trade off against medium run losses. A normative analysis of the optimal policy mix to consolidate debt would be a valuable extension for future research. Furthermore, the results caution against overestimating the positive effects of tax cuts. Labor tax cuts may exhibit multipliers close to zero. In light of soaring public debt levels in major economies, fiscal policy acts not only as a stimulus in times of crises, but unsustainable public debt may become a source of instability by itself. In order to consolidate debt, this paper suggests that cuts in government spending and rising consumption taxes generate output losses and rising unemployment. In contrast, raising labor taxes and transfers may induce substantially smaller losses. The size of these effects depends strongly on the underlying labor market characteristics. For practical policy evaluation, the findings in this paper call for a systematic account of the effects of fiscal policy in line with Cogan et al. (2010) that considers labor market frictions and fiscal rules explicitly.

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Appendix

A Model derivations

Individual wage bargaining

The value of a match for the firm after the current shock realization is known and exogenous separation is

$$\tilde{J}_t = (a_t mc_t - \varepsilon_t - w_t)(1-\tau_t^p) + E_t \Lambda_{t,t+1} J_{t+1}. \tag{29}$$

The future value of a match for the firm before the shock realization is known and before exogenous separation is

$$\begin{aligned} E_t J_{t+1} =& E_t(1-\phi_{t+1}) \int_{-\infty}^{v_{t+1}^f} (a_{t+1} mc_{t+1} - \varepsilon_{t+1} - w_{t+1}) \frac{g(\varepsilon)}{G(v_{t+1}^f)} (1-\tau_{t+1}^p) d\varepsilon_{t+1} \\ & - (1-\phi^x)\phi_{t+1}^e \big(f(1-\tau_{t+1}^p) + V_{t+1}\big) + (1-\phi_{t+1}) E_{t+1} \Lambda_{t+1,t+2} J_{t+2} + \phi^x V_{t+1} \\ =& E_t(1-\phi_{t+1}) \Big[a_{t+1} mc_{t+1} - \int_{-\infty}^{v_{t+1}^f} \frac{\varepsilon_{t+1} g(\varepsilon)}{1-\phi_{t+1}^e} d\varepsilon_{t+1} - \int_{-\infty}^{v_{t+1}^f} \frac{w_{t+1} g(\varepsilon)}{1-\phi_{t+1}^e} d\varepsilon_{t+1} \Big] (1-\tau_{t+1}^p) \\ & - (1-\phi^x)\phi_{t+1}^e \big(f(1-\tau_{t+1}^p) + V_{t+1}\big) + (1-\phi_{t+1}) \Lambda_{t+1,t+2} J_{t+2} + \phi^x V_{t+1}. \end{aligned} \tag{30}$$

The value of a match for an employed worker is

$$W_t(\varepsilon) = w_t(\varepsilon)(1-\tau_t^n) + E_t \Lambda_{t,t+1} \Big[\phi_{t+1} U_{t+1} + (1-\phi_{t+1}) \int_{-\infty}^{v_{t+1}^f} \frac{W_{t+1}(\varepsilon)}{1-\phi_{t+1}^e} g(\varepsilon) d\varepsilon_{t+1} \Big]. \tag{31}$$

The value of an unemployed worker is

$$U_t = b + E_t\Lambda_{t,t+1}\Big[\eta_{t+1}(1-\phi_{t+1})\int_{-\infty}^{v^f_{t+1}}\frac{W_{t+1}(\varepsilon)}{1-\phi^e_{t+1}}g(\varepsilon)d\varepsilon + \big(1-\eta_{t+1}(1-\phi_{t+1})\big)U_{t+1}\Big]. \tag{32}$$

Combining Eq. 31 and 32 yields

$$W_t - U_t = w_t(\varepsilon)(1-\tau^n_t) - b + E_t\Lambda_{t,t+1}\Big[(1-\phi_{t+1})(1-\eta_{t+1})(\int_{-\infty}^{v^f_{t+1}}\frac{W_{t+1}(\varepsilon)}{1-\phi^e_{t+1}}g(\varepsilon)d\varepsilon - U_{t+1})\Big]. \tag{33}$$

Disregarding the bonding critique, i.e., firing costs show up in the bargaining, the optimal Nash wage is given by

$$w_t(\varepsilon) = \arg\max(\tilde{J}_t(\varepsilon) - V_t + f)^{1-\gamma}(W_t(\varepsilon) - U_t)^{\gamma},$$

which results in the following first-order condition (FOC)

$$\begin{aligned}\gamma(\tilde{J}_t(\varepsilon) - V_t + f)\frac{\partial W_t(\varepsilon)}{\partial w_t(\varepsilon)} &= (1-\gamma)(W_t(\varepsilon) - U_t)\frac{-\partial\tilde{J}_t(\varepsilon)}{\partial w_t(\varepsilon)}\\ \gamma(\tilde{J}_t(\varepsilon) + f)(1-\tau^n_t) &= (1-\gamma)(W_t(\varepsilon) - U_t)(1-\tau^p_t).\end{aligned} \tag{34}$$

Iterating one period forward and integrating over[54] $\int_{-\infty}^{v^f_{t+1}}(\cdot)dG(\varepsilon) = \int_{-\infty}^{v^f_{t+1}}(\cdot)g(\varepsilon)d\varepsilon$ yields

$$\begin{aligned}\frac{\gamma}{1-\gamma}E_t\int_{-\infty}^{v^f_{t+1}}\Big[\tilde{J}_{t+1}(\varepsilon)+f\Big]g(\varepsilon)d\varepsilon(1-\tau^n_{t+1}) =& E_t\int_{-\infty}^{v^f_{t+1}}\Big[W_{t+1}(\varepsilon) - U_{t+1}\Big]g(\varepsilon)d\varepsilon(1-\tau^p_{t+1})\\ \frac{\gamma}{1-\gamma}E_t\Big[\int_{-\infty}^{v^f_{t+1}}\tilde{J}_{t+1}(\varepsilon)g(\varepsilon)d\varepsilon + (1-\phi^e_{t+1})f\Big] =& E_t\Big[\frac{1-\tau^p_{t+1}}{1-\tau^n_{t+1}}\int_{-\infty}^{v^f_{t+1}}W_{t+1}(\varepsilon)g(\varepsilon)d\varepsilon\\ &- (1-\phi^e_{t+1})U_{t+1}\Big]\\ \frac{\gamma}{1-\gamma}E_t\frac{1-\tau^n_{t+1}}{1-\tau^p_{t+1}}\Big[\int_{-\infty}^{v^f_{t+1}}\frac{\tilde{J}_{t+1}(\varepsilon)g(\varepsilon)d\varepsilon}{1-\phi^e_{t+1}} + f\Big] =& E_t\int_{-\infty}^{v^f_{t+1}}\frac{W_{t+1}(\varepsilon)g(\varepsilon)d\varepsilon}{1-\phi^e_{t+1}} - U_{t+1}.\end{aligned} \tag{35}$$

[54]Note that $\int_{-\infty}^{v^f_{t+1}} xdG(\varepsilon) = \int_{-\infty}^{v^f_{t+1}} xg(\varepsilon)d\varepsilon = x\int_{-\infty}^{v^f_{t+1}} g(\varepsilon)d\varepsilon = xG(v^f_{t+1}) = x(1-\phi^e_{t+1})$, if x does not depend on ε.

Note that

$$E_t \Lambda_{t,t+1} J_{t+1} = E_t \Lambda_{t,t+1} (1 - \phi_{t+1}) \int_{-\infty}^{v^f_{t+1}} \frac{\tilde{J}_{t+1}(\varepsilon) g(\varepsilon) d\varepsilon}{1 - \phi^e_{t+1}}. \tag{36}$$

From the free-entry condition (Eq. 10 in $t+1$) follows

$$E_t J_{t+1} = E_t (1 - \phi_{t+1}) \int_{-\infty}^{v^f_{t+1}} \frac{\tilde{J}_{t+1}(\varepsilon) g(\varepsilon) d\varepsilon}{1 - \phi^e_{t+1}} = E_t \frac{\kappa(1 - \tau^p_{t+1})}{q(\theta_{t+1})}. \tag{37}$$

As a result,

$$E_t \int_{-\infty}^{v^f_{t+1}} \frac{\tilde{J}_{t+1}(\varepsilon) g(\varepsilon) d\varepsilon}{1 - \phi^e_{t+1}} = \frac{\kappa(1 - \tau^p_{t+1})}{(1 - \phi_{t+1}) q(\theta_{t+1})}. \tag{38}$$

From the FOC of Nash bargaining (Eq. 34) follows by inserting free-entry and Eq. 38

$$\frac{\gamma}{1-\gamma} \frac{1 - \tau^n_t}{1 - \tau^p_t} \left[(a_t mc_t - \varepsilon - w_t(\varepsilon))(1 - \tau^p_t) + E_t \Lambda_{t,t+1} J_{t+1} \right]$$
$$= w_t(\varepsilon)(1 - \tau^n_t) - b + E_t \Lambda_{t,t+1} \Big[(1 - \phi_{t+1})(1 - \eta_{t+1}) \Big(\int_{-\infty}^{v^f_{t+1}} \frac{W_{t+1}(\varepsilon)}{1 - \phi^e_t} g(\varepsilon) d\varepsilon - U_{t+1} \Big) \Big]$$

$$\frac{\gamma}{1-\gamma} \frac{1 - \tau^n_t}{1 - \tau^p_t} \left[(a_t mc_t - \varepsilon - w_t(\varepsilon))(1 - \tau^p_t) + E_t \Lambda_{t,t+1} J_{t+1} \right]$$
$$= w_t(\varepsilon)(1 - \tau^n_t) - b + E_t \Lambda_{t,t+1} \Big[(1 - \phi_{t+1})(1 - \eta_{t+1}) \frac{\gamma}{1-\gamma} \frac{1 - \tau^n_{t+1}}{1 - \tau^p_{t+1}} \Big\{ \int_{-\infty}^{v^f_{t+1}} \frac{\tilde{J}_{t+1}(\varepsilon) g(\varepsilon) d\varepsilon}{1 - \phi^e_{t+1}} + f \Big\} \Big]$$

$$\frac{\gamma}{1-\gamma} \frac{1 - \tau^n_t}{1 - \tau^p_t} \Big[(a_t mc_t - \varepsilon - w_t(\varepsilon))(1 - \tau^p_t) + E_t \Lambda_{t,t+1} \frac{\kappa(1 - \tau^p_{t+1})}{q(\theta_{t+1})} \Big]$$
$$= w_t(\varepsilon)(1 - \tau^n_t) - b + E_t \Lambda_{t,t+1} \Big[(1 - \phi_{t+1})(1 - \eta_{t+1}) \frac{\gamma}{1-\gamma} \frac{1 - \tau^n_{t+1}}{1 - \tau^p_{t+1}} \Big\{ \frac{\kappa(1 - \tau^p_{t+1})}{(1 - \phi_{t+1}) q(\theta_{t+1})} + f \Big\} \Big]$$

$$w_t(\varepsilon) = \gamma \Big(a_t mc_t - \varepsilon + E_t \Lambda_{t,t+1} \frac{\kappa}{q(\theta_{t+1})} \Big[\frac{1 - \tau^p_{t+1}}{1 - \tau^p_t} - (1 - \eta_{t+1}) \frac{1 - \tau^n_{t+1}}{1 - \tau^n_t} \Big] -$$
$$E_t \Lambda_{t,t+1} (1 - \phi_{t+1})(1 - \eta_{t+1}) \frac{1 - \tau^n_{t+1}}{1 - \tau^n_t} \frac{f}{1 - \tau^p_{t+1}} \Big) + (1 - \gamma) \frac{b}{1 - \tau^n_t}. \tag{39}$$

For fixed tax rates ($\tau_t = \tau_{t+1} = \tau$), this equation gives the usual individual Nash wage in search and matching models with firing costs

$$w_t(\varepsilon) = \gamma\Big(a_t mc_t - \varepsilon + \kappa\theta - E_t\Lambda_{t,t+1}(1-\phi_{t+1})(1-\eta_{t+1})\frac{f}{1-\tau^k}\Big) + (1-\gamma)\frac{b}{1-\tau^n}. \tag{40}$$

Optimal price setting

Monopolistic firms maximize profits over the choice of $p_t(i)$

$$E_0\sum_{t=0}^{\infty}\Lambda_{t,t+1}(1-\tau_t^p)\Big[\frac{p_t(i)}{p_t}\tilde{y}_t(i) - mc_t\tilde{y}_t(i) - \frac{\Psi}{2}\Big(\frac{p_t(i)}{p_{t-1}(i)} - 1\Big)^2\tilde{y}_t\Big],$$

which gives the following first order condition[55]

$$\frac{\tilde{y}_t(i)}{p_t} - \nu\frac{\tilde{y}_t(i)}{p_t} + \nu mc_t\frac{\tilde{y}_t(i)}{p_t(i)} - \Psi\Big(\frac{p_t(i)}{p_{t-1}(i)} - 1\Big)\frac{\tilde{y}_t}{p_{t-1}(i)}$$
$$+E_t\Lambda_{t,t+1}\Psi\Big(\frac{p_{t+1}(i)}{p_t(i)} - 1\Big)\frac{\tilde{y}_{t+1}p_{t+1}(i)}{p_t(i)^2}\frac{1-\tau_{t+1}^p}{1-\tau_t^p} = 0.$$

Insert the firm's demand function $\tilde{y}_t(i) = \Big(\frac{p_t(i)}{p_t}\Big)^{-\nu}\tilde{y}_t$ and obtain

$$(1-\nu)\frac{p_t(i)^{-\nu}}{p_t^{1-\nu}}\tilde{y}_t + \nu mc_t\frac{p_t(i)^{-(1+\nu)}}{p_t^{-\nu}}\tilde{y}_t - \Psi\Big(\frac{p_t(i)}{p_{t-1}(i)} - 1\Big)\frac{\tilde{y}_t}{p_{t-1}(i)}$$
$$+E_t\Lambda_{t,t+1}\Psi\Big(\frac{p_{t+1}(i)}{p_t(i)} - 1\Big)\frac{\tilde{y}_{t+1}p_{t+1}(i)}{p_t(i)^2}\frac{1-\tau_{t+1}^p}{1-\tau_t^p} = 0.$$

Multiply by $\frac{p_t}{\tilde{y}_t}$ and obtain

$$(1-\nu)\frac{p_t(i)^{-\nu}}{p_t^{-\nu}} + \nu mc_t\frac{p_t(i)^{-(1+\nu)}}{p_t^{-(1+\nu)}} - \Psi\Big(\frac{p_t(i)}{p_{t-1}(i)} - 1\Big)\frac{p_t}{p_{t-1}(i)}$$
$$+E_t\Lambda_{t,t+1}\Psi\Big(\frac{p_{t+1}(i)}{p_t(i)} - 1\Big)\frac{\tilde{y}_{t+1}p_{t+1}(i)p_t}{\tilde{y}_t p_t(i)^2}\frac{1-\tau_{t+1}^p}{1-\tau_t^p} = 0.$$

In equilibrium, all firms choose the same prices and quantities ($p(i) = p$, $\tilde{y}(i) = \tilde{y}$) and $\frac{p_t}{p_{t-1}} = \pi_t$. Hence,

$$(1-\nu) + \nu mc_t - \Psi\big(\pi_t - 1\big)\pi_t + E_t\Lambda_{t,t+1}\Psi\big(\pi_{t+1} - 1\big)\frac{\tilde{y}_{t+1}}{\tilde{y}_t}\pi_{t+1}\frac{1-\tau_{t+1}^p}{1-\tau_t^p} = 0.$$

[55]Note that the first derivative of the firm's demand function $\tilde{y}_t(i) = \Big(\frac{p_t(i)}{p_t}\Big)^{-\nu}\tilde{y}_t$ is $\frac{\partial\tilde{y}_t(i)}{\partial p_t(i)} = -\nu\frac{\tilde{y}_t(i)}{p_t(i)}$.

B Data description

Data construction and sources

If necessary, series are seasonally adjusted using Census-X12-ARIMA. NIPA and VGR refer to the official national accounts as reported by the *Bureau of Economic Analysis* of the US and the *Statistische Bundesamt* of Germany, respectively. In case of a break in German data due to reunification in 1991, the German series are linked to the earlier West German series using growth rates.

General variables

- Gross domestic product (GDP): Real per capita GDP (NIPA/VGR). The nominal gross series is scaled with the GDP deflator and the labor force (NIPA/VGR).
- Inflation (yoy): Log difference of the GDP deflator in t and $t-4$ (NIPA/VGR).
- Interest rates: For the US, I use the official federal funds rate; for Germany, I use the 3-months interbank rate of the Deutsche Bundesbank. Series are averaged to quarterly frequency.

Labor market variables

- Official unemployment rate (Bureau of Labor Statistics (BLS)/Federal Employment Agency).
- Job-finding and separation rates: For the US, I update the series of Shimer (2012) until 2011Q4. Labor market flows are deduced from data on employment, unemployment and short-term unemployment. The monthly US series is converted to quarterly terms as follows: The probability to find a job/lose a job in at least one of the three months is $\eta_q = 1-(1-\eta_{m1}) \times (1-\eta_{m2}) \times (1-\eta_{m3})$, etc. The German flow rates are constructed by Gartner et al. (2012) from German administrative data (due to data quality problems, I use the series only from 1982 onwards).

Fiscal variables

- Government spending: For the US, government consumption expenditures and gross investment (NIPA). For Germany, sum of government consumption and government gross fixed capital formation (VGR). Series are transformed to real per capita terms and are seasonally adjusted.

- Government debt: Real per capita debt. For the US, market value of federal debt held by public from the Dallas Federal Reserve (see Zubairy, 2014). For Germany, central, state, and local government debt from Deutsche Bundesbank.

- Effective tax rates on labor, profits and consumption (see below).

Constructing effective tax rates

In order to obtain effective tax rates for consumption, labor, and profit taxes, I follow Mendoza et al. (1994). The calculation uses data from the *OECD Revenue Statistics* and detailed national accounts that is partly only available at annual frequency. I follow the method proposed by Forni et al. (2009) to interpolate the annual series using quarterly indicators with Chow and Lin (1971) and Santos Silva and Cardoso (2001). Table 9 summarizes the variables and data series used in constructing the tax rates (notation follows Mendoza et al., 1994).[56]

Following Mendoza et al. (1994), the tax rates are computed as

1. Effective tax rate on consumption

$$\tau_c = \left[\frac{5110 + 5121}{C + G - GW - 5110 - 5121}\right] \times 100$$

2. Household's average tax rate on total income:

$$\tau_h = \left[\frac{1100}{OSPUE + PEI + W}\right] \times 100$$

3. Effective tax rate on labor income:

$$\tau_w = \left[\frac{\tau_h W + 2000 + 3000}{W + 2200}\right] \times 100$$

4. Effective tax rate on capital income:

$$\tau_p = \left[\frac{\tau_h(OSPUE + PEI) + 1200 + 4100 + 4400}{OS}\right] \times 100.$$

US tax rates For the US, quarterly revenue data is available as part of the official NIPA tables (see Jones, 2002). The only variables that are required for the Mendoza et al. (1994)

[56] I thank Kilian Ruppert for highly appreciated help with the construction of the tax rates.

calculations and that are not available at quarterly frequency are taxes on payroll and workforce, taxes on financial and capital transactions, general taxes on goods and services, and excise taxes. I follow the proposition of Forni et al. (2009) and interpolate to quarterly levels using wages, private and public consumption, or a linear trend in the case of taxes on financial and capital transactions. The US series span from 1965Q1 to 2011Q4.

German tax rates For Germany, detailed revenue statistics are only available at annual frequency as part of the *OECD Revenue Statistics*. National accounts data at the level required here is available in the *Annual Macroeconomic Database* (AMECO). The same data is used by Trabandt and Uhlig (2011). The annual series are interpolated following Forni et al. (2009). Quarterly indicators are value added, wages, consumption, and social security contributions (see Table 9 for details). Due to lack of an appropriate indicator, recurrent taxes on immovable property and taxes on financial and capital transactions are interpolated using a linear trend. The German series span 1980Q1 to 2011Q4 (data series before 1991 refer to West Germany only). The start of the series is limited by data availability of the AMECO series for the operating surplus of private unincorporated enterprises and the households' property and entrepreneurial income.

Figure 7 shows the tax rates (aggregated to annual levels) in comparison to the annual effective tax rates constructed by Mendoza et al. (1994) and Trabandt and Uhlig (2011). The series constructed here are very close to the most recent data of Trabandt and Uhlig (2011) and also fit the overall movement of the Mendoza et al. (1994) data. Figure 8 shows the quarterly effective tax rates that are used in the estimation.

Variable	Description	Data source [quarterly indicator if interpolation is necessary] US	Germany
Revenue statistics			
1100	Taxes on income, profits, and capital gains of individuals	NIPA (3.1: line 3+3.2: line 3)	OECD [value added (VGR, 1.13: column 5)]
1200	Taxes on income, profits, and capital gains of corporations	NIPA (3.1: line 5)	OECD [value added (VGR, 1.13: column 5)]
2000	Total social security contributions	NIPA (3.1: line 7)	OECD [total social security contributions (VGR, 1.8: column 2+5)]
2200	Employer's contribution to social security	NIPA (1.12: line 8)	OECD [employer's contr. to social security (VGR, 1.8: column 2)]
3000	Taxes on payroll an workforce	OECD [wages]	OECD [wages]
4100	Recurrent taxes on immovable property	NIPA (3.3: line 8)	OECD [linear trend]
4400	Taxes on financial and capital transactions	OECD [linear trend]	OECD [linear trend]
5110	General taxes on goods and services	OECD [private and public consumption]	OECD [private and public consumption]
5121	Excise taxes	OECD [private and public consumption]	OECD [private and public consumption]
National accounts			
C	Private final consumption expenditure	NIPA (1.5: line 2)	VGR (3.1: column 4)
G	Government final consumption expenditure	NIPA (1.5: line 22)	VGR (3.1: column 5)
GW	Compensation of employees paid by producers of gvmt. services	NIPA (3.10.5: line 4)	AMECO (UWCG) [public consumption (VGR)]
OSPUE	Operating surplus of private unincorporated enterprises	NIPA (1.12: line 12 + 13 + 18)	AMECO (UOGH) [profits (VGR, 1.3: column 3)]
PEI	Household's property and entrepreneurial income	NIPA (1.12: line 9)	AMECO (UYNH) [profits (VGR, 1.3: column 3)]
W	Wages and salaries	NIPA (1.12: line 3)	VGR (1.8: column 3)
OS	Total operating surplus of the economy	NIPA (1.10: line 9)	AMECO (UOND) [profits (VGR, 1.3: column 3)]

Table 9: Constructing quarterly effective tax rates. OECD refers to the *OECD Revenue Statistics*. AMECO is the annual macroeconomic database of the European Commission. NIPA and VGR refer to the official national accounts as reported by the *Bureau of Economic Analysis* of the US and the *Statistische Bundesamt* of Germany, respectively.

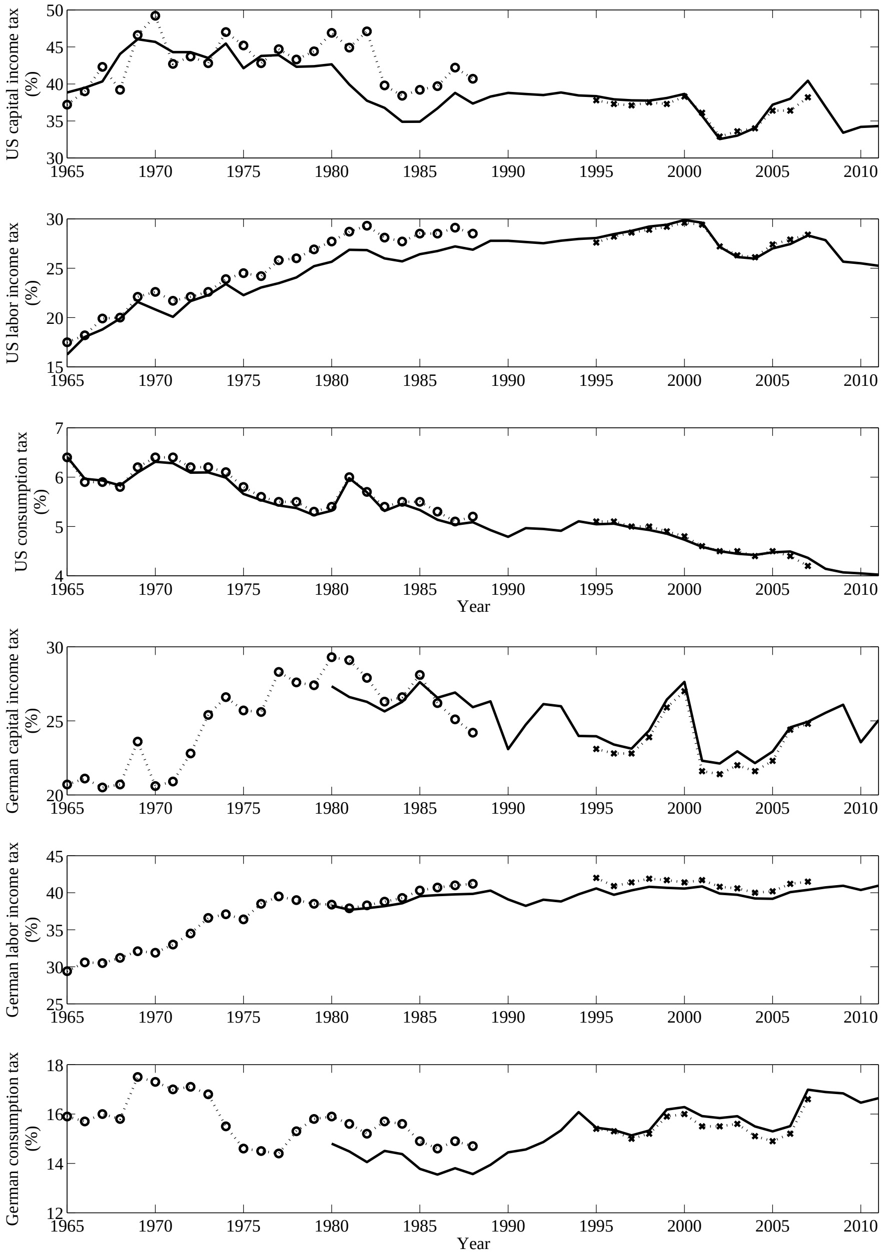

Figure 7: Annual effective tax rates. Comparison of data constructed here (solid lines), data of Mendoza et al., 1994 (lines marked by dots), and the data series computed by Trabandt and Uhlig, 2011 (lines marked by crosses).

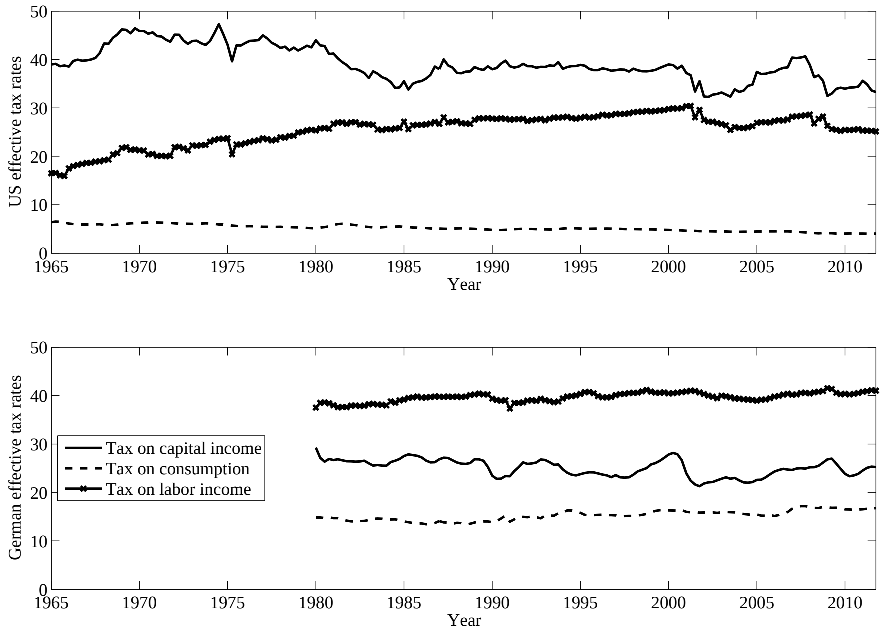

Figure 8: Quarterly effective tax rates in the US and Germany.

C Estimation output and model fit

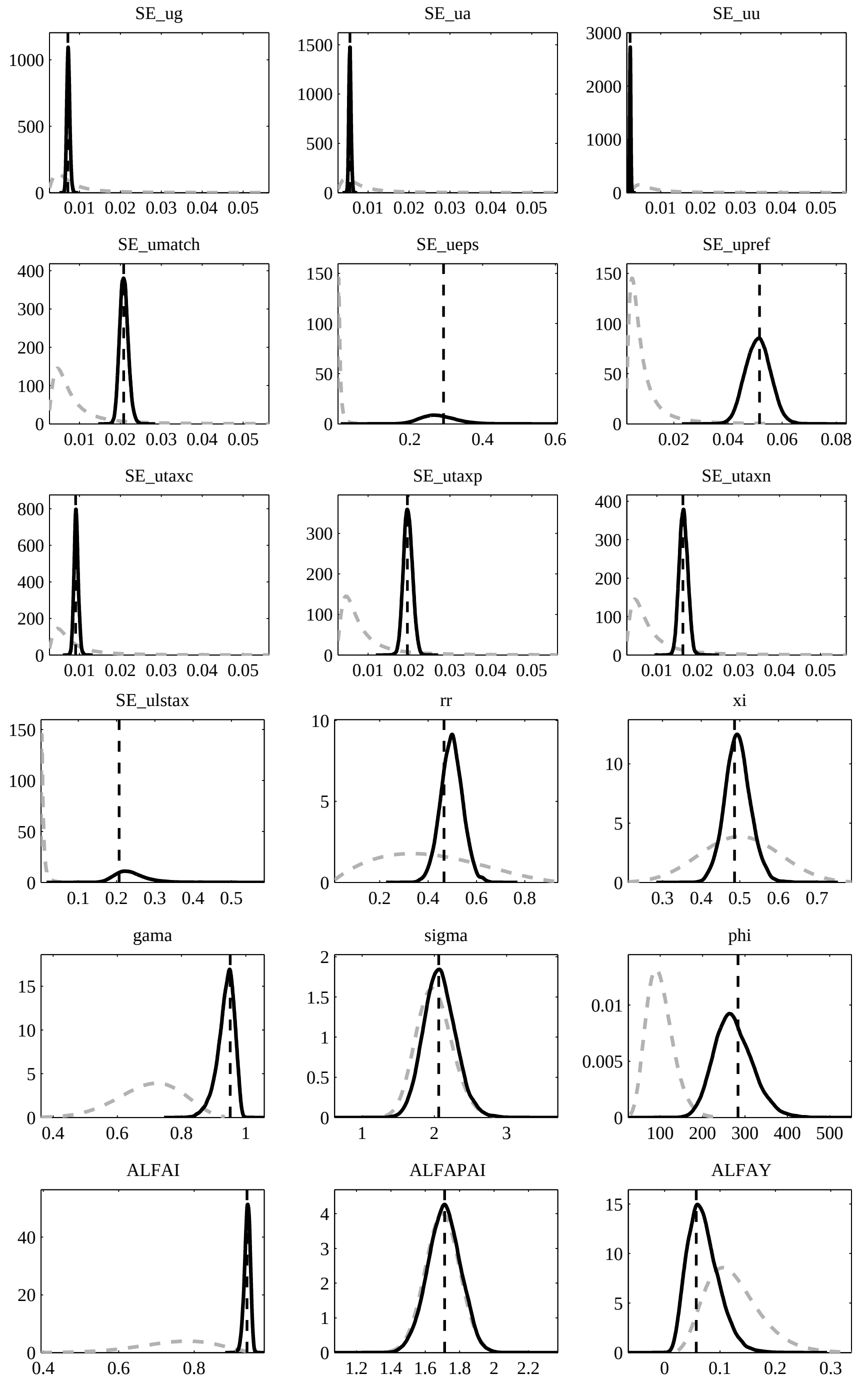

Figure 9: Prior (dashed grey) and posterior distributions (solid black) for baseline estimation (US). The vertical lines mark the posterior mode.

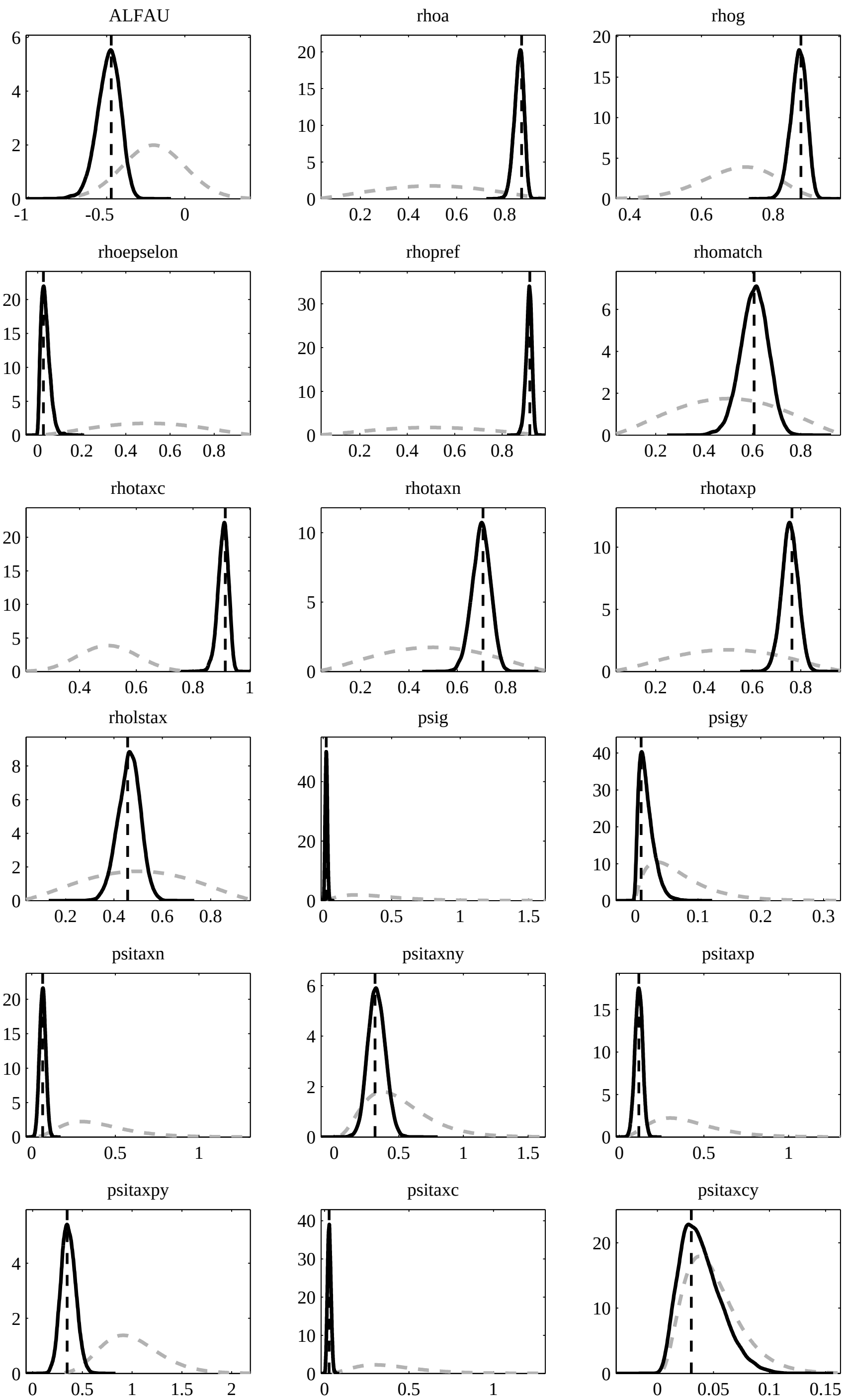

Figure 10: Prior (dashed grey) and posterior distributions (solid black) for baseline estimation (US, ctd.). The vertical lines mark the posterior mode.

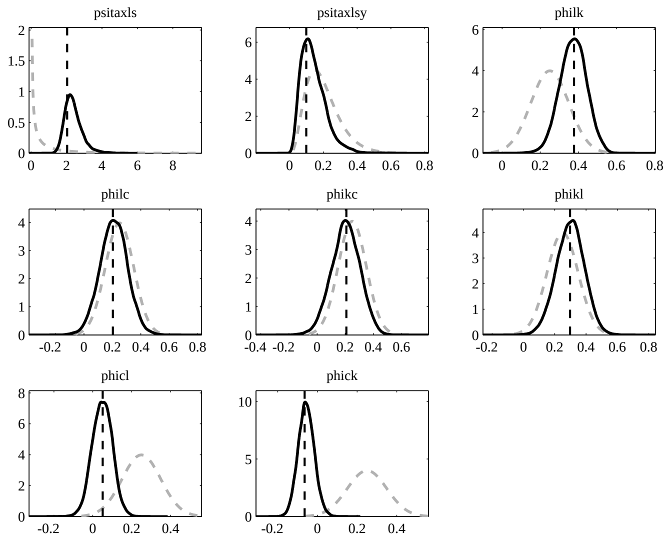

Figure 11: Prior (dashed grey) and posterior distributions (solid black) for baseline estimation (US, ctd.). The vertical lines mark the posterior mode.

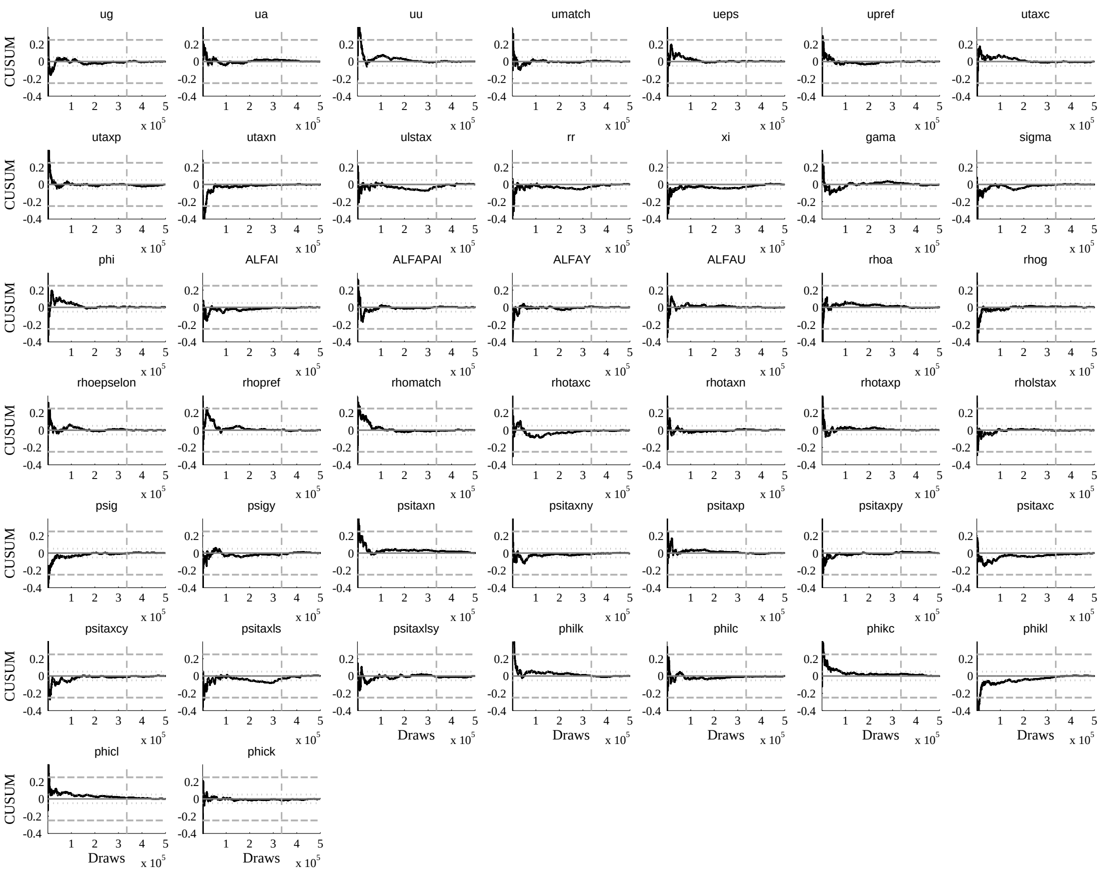

Figure 12: CUSUM charts for baseline estimation of US model. The horizontal lines indicate 5 and 25 percent bands. The vertical line indicates the burn-in of the Markov chain.

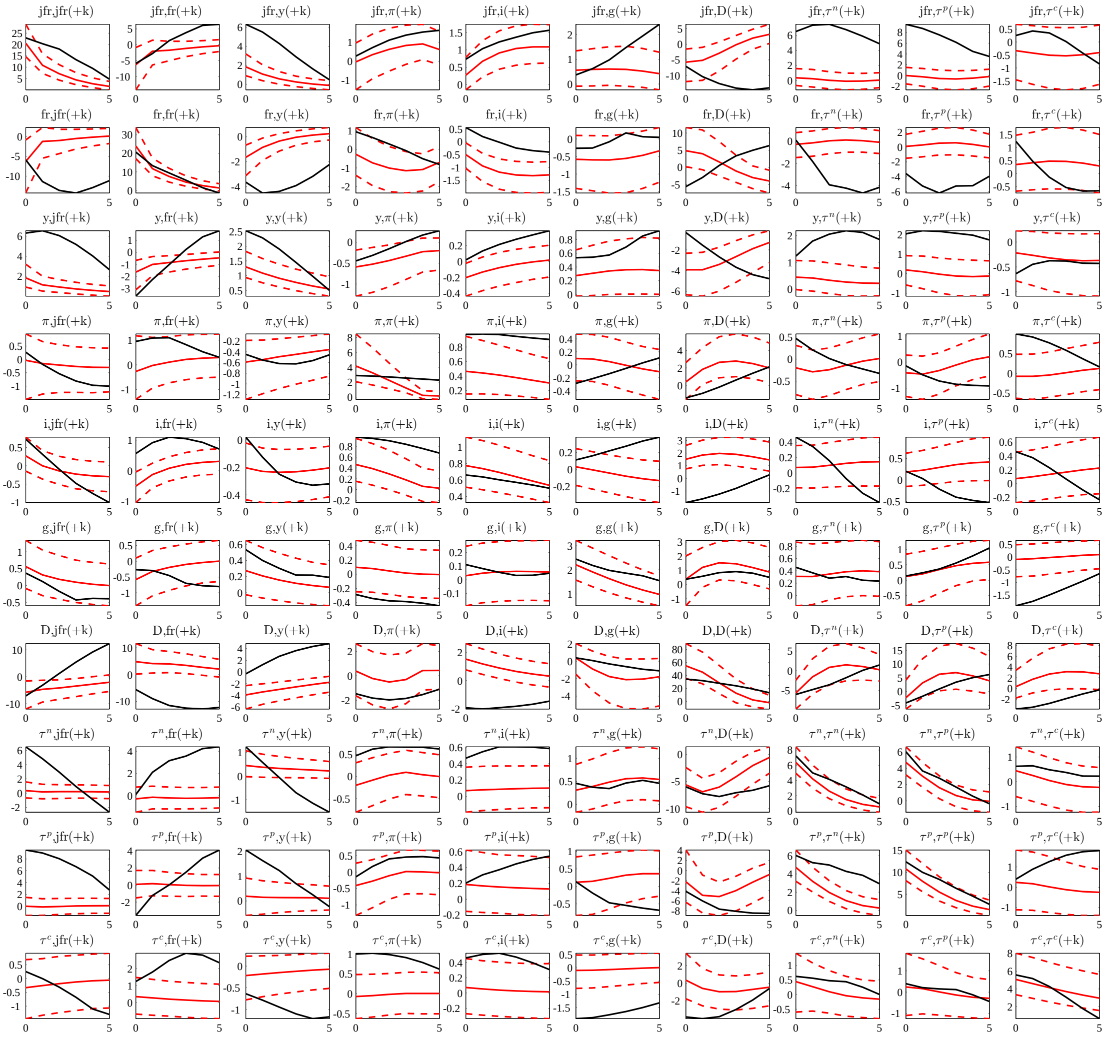

Figure 13: Auto- and cross-covariances at t and $t+k$ of US data (black solid line) and estimated model (red lines, dashed lines represent 5th and 95th percentiles, solid lines represent the posterior median). Model covariances are computed from simulated data as follows: I took 500 draws from the posterior distribution and simulated 100 samples for each draw of the same size as the observed data series after a burn-in of $1,000$ periods. The diagonal elements show auto-covariances, off-diagonal elements show cross-covariances.

D Model responses under alternative fiscal rules

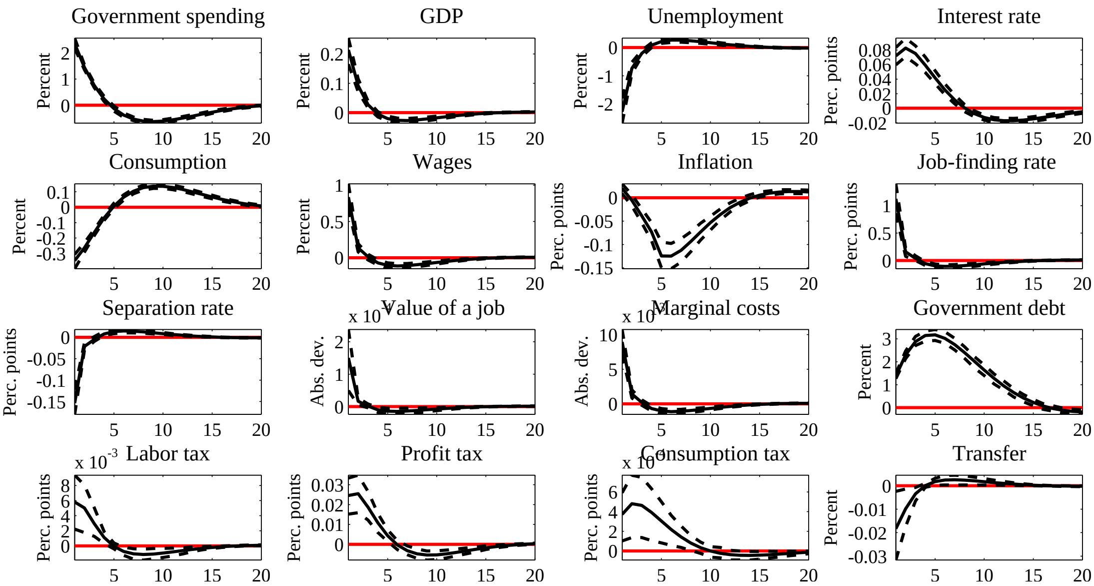

Figure 14: Estimated impulse responses to an increase in government spending (0.5 percent of GDP) in the US if only government spending adjusts to debt. The solid line shows the impulse responses at the posterior mean; the dashed lines at the 5 percent and 95 percent posterior intervals. The impulse horizon is measured in quarters.

E Details on the robustness check for Germany

Collective wage bargaining

The following section discusses the model modification in order to estimate the model with a frictional labor market for Germany. To replicate German labor market institutions, I replace the individual wage bargaining with collective wage bargaining. This implies that firms bargain with the median worker, i.e., the worker with the median ε^M realization. This collective wage then applies to all worker-firm matches. The wage is set to maximize the Nash product $(\tilde{J}_t(\varepsilon^M) - S_t^f)^{1-\gamma}(W_t - S_t^w)^\gamma$. In case of collective bargaining, a split of the match in case of disagreement is unrealistic, as this would imply that all matches are split at once. I follow Faia et al. (2013) and assume that the outside option of the firm is a fixed cost of strike s, the outside option of the worker is the unemployment benefit b. Moreover, current disagreement does not affect future values. The optimal wage from Nash bargaining for all workers, irrespective of their idiosyncratic ε realization, under collective agreement is then

$$w_t = \gamma\Big(a_t mc_t - \varepsilon^M + \frac{s}{1-\tau_t^p}\Big) + (1-\gamma)\frac{b}{1-\tau_t^n}. \tag{41}$$

Derivation of collective Nash wages Let $\tilde{J}_t^M$ denote the current value of a job for the firm that employs the median worker. Disagreement generates a fixed cost of strike. The optimal wage maximizes

$$w_t = \arg\max(\tilde{J}_t^M - S_t^f)^{1-\gamma}(W_t - S_t^w)^\gamma. \tag{42}$$

The outside option of firm in case of disagreement is the fixed costs of strike s^f plus the future value of a match $S_t^f = -s^f + E_t\Lambda_{t,t+1}J_{t+1}$. I assume that future values are not affected by current disagreement. The outside option of the worker is the fixed costs of strike s^w plus the future value of a match for the worker $S_t^w = s^w + E_t\Lambda_{t,t+1}\big((1-\phi_t)W_{t+1} + \phi_t U_{t+1}\big)$. Again, I assume that future values are not affected by current disagreement. Then, Eq. 42 becomes

$$\max\Big((a_t mc_t - \varepsilon^M - w_t)(1-\tau_t^p) + E_t\Lambda_{t,t+1}J_{t+1} - (-s^f + E_t\Lambda_{t,t+1}J_{t+1})\Big)^{1-\gamma}$$
$$\Big(w_t(1-\tau_t^n) + E_t\Lambda_{t,t+1}\big(\phi_t U_{t+1} + (1-\phi_t)W_{t+1}\big) - (s^w + E_t\Lambda_{t,t+1}\big((1-\phi_t)W_{t+1} + \phi_t U_{t+1}))\Big)^\gamma$$

$$\max\Big((a_t mc_t - \varepsilon^M - w_t)(1-\tau_t^p) + s^f\Big)^{1-\gamma}\Big(w_t(1-\tau_t^n) - s^w\Big)^\gamma. \tag{43}$$

Maximization gives

$$(1-\gamma)\Big((a_t mc_t - \varepsilon^M - w_t)(1-\tau_t^p) + s^f\Big)^{-\gamma}(1-\tau_t^p)(-1)\Big(w_t(1-\tau_t^n) - s^w\Big)^{\gamma}$$
$$+\gamma\Big(w_t(1-\tau_t^n) - s^w\Big)^{\gamma-1}(1-\tau_t^n)\Big((a_t mc_t - \varepsilon^M - w_t)(1-\tau_t^p) + s^f\Big)^{1-\gamma} = 0$$

$$(1-\gamma)\Big((a_t mc_t - \varepsilon^M - w_t)(1-\tau_t^p) + s^f\Big)^{-\gamma}(1-\tau_t^p)\Big(w_t(1-\tau_t^n) - s^w\Big)^{\gamma}$$
$$=\gamma\Big(w_t(1-\tau_t^n) - s^w\Big)^{\gamma-1}(1-\tau_t^n)\Big((a_t mc_t - \varepsilon^M - w_t)(1-\tau_t^p) + s^f\Big)^{1-\gamma}$$

$$(1-\gamma)(1-\tau_t^p)\Big(w_t(1-\tau_t^n) - s^w\Big) = \gamma(1-\tau_t^n)\Big((a_t mc_t - \varepsilon^M - w_t)(1-\tau_t^p) + s^f\Big). \tag{44}$$

Rearranging defines the optimal Nash wage in case of collective bargaining as

$$w_t = \gamma\Big(a_t mc_t - \varepsilon^M + \frac{s^f}{1-\tau_t^p}\Big) + (1-\gamma)\frac{s^w}{1-\tau_t^n}. \tag{45}$$

Estimation and results for Germany

This section contains details on the model estimation with German data.[57] Steady state targets for flow rates, taxes, spending and government debt are adjusted accordingly. The German time series span from 1982Q1 to 2004Q4. The sample is remarkably shorter than for the US and limited by the availability of the flow rate data. The differences in the estimated German and the estimated US model are not due to the different data periods. In order to rule this out, I re-estimated the baseline US model with the same shorter data sample as in the German case. The results are robust to this modification. In the German data, the average quarterly job-finding rate is 25.6 percent. The average quarterly separation rate is 2.4 percent. On average, the government spends 21.8 percent of GDP and the government debt to GDP ratio amounts to 47.8 percent of GDP. Labor tax rates are on average higher in Germany (39.5 percent), in contrast, the profit tax is rather moderate (25.2 percent). Consumption is taxed with 14.9 percent, on average. The German labor market is characterized by positive firing cost. I follow Thomas and Zanetti (2009) and set firing cost f to 20 percent of the quarterly wage.

Average real returns in the German sample are 3.27 percent generating a discount factor of 0.9920. The average job-finding rate is targeted using the costs of a strike s (in contrast to vacancy posting costs κ under individual bargaining). Following Christoffel et al. (2009) for

[57] As in the US, also in Germany, most of the hours adjustment is pursued along the extensive margin (Merkl and Wesselbaum, 2011). This observation holds at least outside of large recessions (Burda and Hunt, 2011).

	Definition	Value	
		US	Germany
β	Discount factor	0.9944	0.9920
ν	Elasticity of substitution	10	10
f	Firing costs	0	$0.2w$
a_1	Mean of idiosyncratic shock distribution	0	0
π	Gross inflation	1	1
η	Job-finding rate	0.7939	0.2555
ϕ	Separation rate	0.0975	0.0239
$q(\theta)$	Worker finding rate	0.7	0.7
ϕ^x	Exogenous separations	0.065	0.0159
g/y	Government spending (relative to GDP)	0.2081	0.2181
D/y	Government debt (relative to GDP)	0.3199	0.4776
τ^n	Labor tax rate	0.2543	0.3949
τ^k	Profit tax rate	0.3907	0.2517
τ^c	Consumption tax rate	0.0518	0.1492

Table 10: Fixed parameters and steady state targets in the US and the German model. Quarterly calibration. Annual productivity is normalized to 1.

Germany, the average quarterly worker finding rate is targeted at 70 percent. Table 10 contrasts the German steady state targets with the baseline US calibration. For the German estimation, I use the same prior distributions as in the US case. Due to the different bargaining setting, I additionally estimate the vacancy posting costs κ. The costs of a strike, s, gives one additional degree of freedom in the estimation. I set a Gamma prior with mean 0.05 and standard deviation 0.05 (Lubik, 2009).

Table 11 summarizes the estimated mean and 5 and 95 percentiles of the posterior distribution for Germany. Most of the posterior estimates are in a similar range compared to the baseline US setting. Monetary policy in Germany reacts stronger to the output gap, but less strong to the unemployment gap. The estimated labor market parameters differ between the US and Germany. The elasticity of the matching function with respect to unemployment, α, is higher in Germany with 0.90. The German estimation is very informative for this parameter. The bargaining power is in the medium range with $\gamma = 0.43$. The replacement rate is relatively low (0.37). One possible interpretation is that the parameter not only captures monetary compensation in case of unemployment, but also the value of general non-work activities (Monacelli et al., 2010). Note that the lower bargaining power of workers in Germany compared to the US does not imply that workers receive lower wages in Germany. Instead, due to collective bargaining, all workers receive the same wage irrespective of the idiosyncratic productivity realization. Consequently, wages of low productivity workers are substantially higher compared to the US, whereas wages of high productivity workers are substantially lower than in

		Prior mean	Posterior Mean	Posterior 90% interval
Price setting, monetary policy and preferences				
Price adjustment costs	Ψ	100.00	316.2324	[255.29; 377.06]
Relative risk aversion	σ	2.00	1.9989	[1.92; 2.08]
Interest rate smoothing	ρ_i	0.75	0.9543	[0.94; 0.97]
Taylor rule response to inflation	ξ_π	1.70	1.6737	[1.51; 1.84]
Taylor rule response to output	ξ_y	0.12	0.1439	[0.06; 0.23]
Taylor rule response to unemployment	ξ_u	-0.20	-0.2955	[-0.42; -0.18]
Labor market				
Bargaining power	γ	0.50	0.4304	[0.36; 0.50]
Matching elasticity on unemployment	α	0.5	0.9081	[0.83; 0.98]
Replacement rate	rr	0.5	0.3739	[0.31; 0.44]
Vacancy posting costs	κ	0.05	0.0167	[0.00; 0.03]
Fiscal policy				
Feedback of gvmt. debt on gvmt. spending	ψ_g	0.40	0.0539	[0.02; 0.08]
Feedback of gvmt. debt on consumption taxes	ψ_{τ^c}	0.40	0.0653	[0.02; 0.10]
Feedback of gvmt. debt on profit taxes	ψ_{τ^k}	0.40	0.1940	[0.10; 0.28]
Feedback of gvmt. debt on labor taxes	ψ_{τ^w}	0.40	0.0477	[0.02; 0.07]
Feedback of gvmt. debt on transfers	$\psi_{\tau^{ls}}$	0.40	1.2203	[1.01; 1.43]
Feedback of output on gvmt. spending	$\psi_{g,y}$	0.07	0.0273	[0.00; 0.05]
Feedback of output on consumption tax	$\psi_{\tau^c,y}$	0.05	0.0479	[0.01; 0.08]
Feedback of output on profit tax	$\psi_{\tau^k,y}$	1.00	0.6704	[0.46; 0.88]
Feedback of output on labor tax	$\psi_{\tau^w,y}$	0.50	0.0746	[0.03; 0.12]
Feedback of output on transfer	$\psi_{\tau^{ls},y}$	0.20	0.0990	[0.02; 0.17]
Co-movement of profit and labor tax	ζ_{kl}	0.25	0.2397	[0.08; 0.40]
Co-movement of profit and consumption tax	ζ_{kc}	0.25	0.2269	[0.07; 0.38]
Co-movement of labor and profit tax	ζ_{lk}	0.25	0.0394	[-0.00; 0.08]
Co-movement of labor and consumption tax	ζ_{lc}	0.25	0.0134	[-0.05; 0.07]
Co-movement of consumption and profit tax	ζ_{ck}	0.25	0.1558	[0.06; 0.26]
Co-movement of consumption and labor tax	ζ_{cl}	0.25	0.2190	[0.06; 0.38]

Table 11: Posterior distributions of parameters for Germany. The posterior is explored using the random-walk metropolis hastings algorithm with $500,000$ draws. I discard the first $250,000$ draws. The average acceptance rate is 0.35. The log marginal data density is computed using the modified harmonic mean estimator.

the US. For the fiscal policy parameters, in general, the German economy features larger fiscal adjustment parameters in response to the debt level. The US adjusts more through lump-sum transfers.

Table 13 summarizes the forecast error variance decomposition of the estimated model for Germany. German labor market flows move due to preference, productivity, matching and monetary policy shocks. Productivity shocks explain approximately 36 percent. They are relatively

		Prior mean	Posterior Mean	Posterior 90% interval
Autoregressive parameters				
Productivity	ρ_a	0.50	0.7758	[0.74; 0.82]
Government spending	ρ_g	0.50	0.7884	[0.74; 0.84]
Matching efficiency	ρ_μ	0.50	0.3632	[0.21; 0.51]
Price mark-up	ρ_φ	0.50	0.0412	[0.01; 0.07]
Preferences	ρ_d	0.50	0.8758	[0.84; 0.92]
Consumption taxes	ρ_{τ^c}	0.50	0.7147	[0.64; 0.80]
Labor taxes	ρ_{τ^w}	0.50	0.7765	[0.70; 0.85]
Profit taxes	ρ_{τ^k}	0.50	0.8627	[0.82; 0.91]
Transfers	$\rho_{\tau^{ls}}$	0.50	0.3551	[0.25; 0.45]
Standard deviations				
Monetary policy	σ_m	0.01	0.0016	[0.00 ; 0.00]
Productivity	σ_a	0.01	0.0094	[0.01 ; 0.01]
Government spending	σ_g	0.01	0.0097	[0.01 ; 0.01]
Matching efficiency	σ_μ	0.01	0.0505	[0.04 ; 0.06]
Price mark-up	σ_φ	0.01	0.2330	[0.18 ; 0.28]
Preferences	σ_d	0.01	0.0331	[0.03 ; 0.04]
Consumption taxes	σ_{τ^c}	0.01	0.0140	[0.01 ; 0.02]
Profit taxes	σ_{τ^k}	0.01	0.0224	[0.02 ; 0.03]
Labor taxes	σ_{τ^w}	0.01	0.0052	[0.00 ; 0.01]
Transfers	$\sigma_{\tau^{ls}}$	0.01	0.0533	[0.05 ; 0.06]
log marginal data density			-1,764.74	

Table 12: Posterior distribution of the shock processes in Germany. The posterior is explored using the random-walk metropolis hastings algorithm with $500,000$ draws. I discard the first $250,000$ draws. The average acceptance rate is 0.36. The log marginal data density is computed using the modified harmonic mean estimator.

more important for labor market flows than in the US. Productivity and preference shocks explain each approximately 40 percent of the forecast error variance of German unemployment rates. Monetary policy shocks explain approximately 10 percent of German labor market dynamics, i.e., less than in the US. Matching shocks explain only 10 percent of German labor market flows. On average, fiscal policy is not important for labor market variables.

The results fit to SVAR evidence for Germany. Bachmann and Balleer (2010) find that demand shocks are of particular importance for the job-finding rate. The explained variance share of productivity shocks in flow rates is of comparable size as in Nordmeier and Weber (2013). Nordmeier and Weber (2013) identify productivity, monetary and fiscal shocks in German flow rate data using a mixture of long run and short run identifying restrictions. Further, they argue that monetary policy is only relevant for the long run movement of the job-finding rate (and even then, effects are not large). They also find that fiscal policy is only relevant in the very short run and only for the dynamics of the separation rate.

	Productivity shock		Monetary shock		Spending shock		Mark-up shock		Preference shock		Matching shock		Transfer shock		Tax shocks	
Horizon	Mean	90% interval	Mean	90% interval	Mean	90% interval	Mean	90% interval	Mean	90% interval	Mean	90% interval	Mean	90% interval	Mean	90% interval
Variance decomposition of the job-finding rate																
1	0.43	[0.37; 0.49]	0.09	[0.06; 0.11]	0.02	[0.02; 0.03]	0.01	[0.00; 0.02]	0.33	[0.25; 0.41]	0.11	[0.09; 0.13]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
5	0.43	[0.37; 0.49]	0.09	[0.06; 0.11]	0.02	[0.02; 0.03]	0.01	[0.00; 0.02]	0.32	[0.25; 0.40]	0.12	[0.10; 0.16]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
20	0.43	[0.37; 0.49]	0.09	[0.06; 0.11]	0.02	[0.02; 0.03]	0.01	[0.00; 0.02]	0.32	[0.25; 0.40]	0.12	[0.10; 0.16]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
Variance decomposition of the separation rate																
1	0.44	[0.38; 0.50]	0.09	[0.07; 0.11]	0.02	[0.02; 0.03]	0.01	[0.00; 0.02]	0.34	[0.26; 0.42]	0.09	[0.08; 0.11]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
5	0.44	[0.38; 0.50]	0.09	[0.07; 0.11]	0.02	[0.02; 0.03]	0.01	[0.00; 0.02]	0.33	[0.25; 0.41]	0.10	[0.08; 0.12]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
20	0.44	[0.38; 0.50]	0.09	[0.07; 0.11]	0.02	[0.02; 0.03]	0.01	[0.00; 0.02]	0.33	[0.25; 0.41]	0.10	[0.08; 0.12]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
Variance decomposition of unemployment																
1	0.49	[0.41; 0.55]	0.10	[0.07; 0.12]	0.03	[0.02; 0.03]	0.01	[0.00; 0.02]	0.37	[0.29; 0.46]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
5	0.41	[0.37; 0.46]	0.14	[0.10; 0.17]	0.02	[0.02; 0.02]	0.02	[0.00; 0.03]	0.41	[0.35; 0.47]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
20	0.40	[0.35; 0.45]	0.15	[0.11; 0.19]	0.02	[0.02; 0.02]	0.02	[0.01; 0.03]	0.40	[0.34; 0.47]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
Variance decomposition of GDP																
1	0.26	[0.19; 0.33]	0.14	[0.10; 0.19]	0.04	[0.03; 0.05]	0.02	[0.00; 0.03]	0.54	[0.44; 0.62]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.01	[0.01; 0.01]
5	0.38	[0.30; 0.46]	0.15	[0.11; 0.19]	0.02	[0.02; 0.03]	0.02	[0.00; 0.03]	0.43	[0.35; 0.51]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]
20	0.46	[0.36; 0.55]	0.14	[0.09; 0.18]	0.02	[0.01; 0.02]	0.02	[0.00; 0.03]	0.36	[0.27; 0.43]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]	0.00	[0.00; 0.00]

Table 13: Posterior forecast error variance decomposition for Germany. The forecast horizon is measured in quarters.

Horizon	*Spending multipliers* GDP	Unemployment	*Transfer multipliers* GDP	Unemployment	*Labor tax multipliers* GDP	Unemployment	*Consumption tax multipliers* GDP	Unemployment
	All instruments adjust (-1,764.74)							
1	0.620 [0.55; 0.69]	-0.573 [-0.63; -0.47]	0.023 [0.02; 0.03]	-0.021 [-0.03; -0.01]	0.028 [0.00; 0.05]	-0.025 [-0.05; -0.00]	0.317 [0.29; 0.35]	-0.293 [-0.32; -0.26]
5	0.437 [0.37; 0.50]	-0.371 [-0.43; -0.31]	-0.309 [-1.11; -0.16]	0.264 [0.13; 0.96]	-0.005 [-0.03; 0.02]	0.005 [-0.02; 0.02]	0.195 [0.16; 0.23]	-0.165 [-0.20; -0.14]
20	0.125 [0.08; 0.17]	-0.106 [-0.14; -0.07]	-0.141 [-0.22; -0.10]	0.120 [0.08; 0.19]	0.017 [-0.02; 0.06]	-0.014 [-0.05; 0.02]	0.031 [0.00; 0.05]	-0.026 [-0.05; -0.00]
	Only transfers adjust, no fiscal rules (-1,768.71)							
1	0.545 [0.44; 0.65]	-0.498 [-0.59; -0.40]	0	0	-0.045 [-0.12; -0.02]	0.040 [0.02; 0.10]	0.271 [0.21; 0.30]	-0.244 [-0.28; -0.19]
5	0.401 [0.31; 0.51]	-0.343 [-0.43; -0.26]	0	0	0.004 [-0.03; 0.03]	-0.004 [-0.02; 0.03]	0.193 [0.15; 0.23]	-0.163 [-0.20; -0.13]
20	0.185 [0.14; 0.26]	-0.158 [-0.22; -0.12]	0	0	0.082 [0.05; 0.13]	-0.071 [-0.11; -0.04]	0.090 [0.07; 0.12]	-0.076 [-0.10; -0.06]

Table 14: Fiscal multipliers for Germany. Numbers show the posterior median and the 5 and 95 percent posterior intervals. Multipliers are present value multipliers. Multipliers are reported for an increase in spending and transfers and for cuts in taxes. Numbers in paranthesis indicate the log marginal data density of each specification (based on the modified harmonic mean estimator).

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