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PATTERNS OF UNEMPLOYMENT DYNAMICS IN GERMANY

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Using a structural vector autoregressive (SVAR) model, this paper provides deeper insight into unemployment dynamics in Germany. We identify a technology shock and two policy shocks that play a central role in business cycle research. Accordingly, we enrich the discussion on the sources of unemployment dynamics by considering demand-side impulses. The worker reallocation process varies substantially with the identified shocks. The job-finding rate plays a larger role after a technology shock and a monetary policy shock, whereas the separation rate appears to be the dominant margin after a fiscal policy shock. Technology shocks turn out to be relatively important for variations in the transition rates. Regarding policy shocks, our results point toward fiscal interventions as a promising instrument but with several limitations.

Keywords: Unemployment Dynamics, Transition Rates, SVAR, Policy Shocks

1. INTRODUCTION

Unemployment dynamics receive substantial attention in business cycle research. Their net changes shape the adjustment of unemployment and are an important indicator of the economic situation. A high magnitude of unemployment dynamics, on the one hand, implies labor market flexibility but, on the other hand, creates considerable uncertainty among workers.

The objective of this paper is to investigate the patterns of unemployment dynamics in Germany. The German case is attractive due to its labor market development, which is significantly different from that of the United States. The primary aim is to provide deeper insight into the worker reallocation process, i.e., the flows in and out of unemployment. For this purpose, we employ a structural vector autoregressive (SVAR) model and specify different shocks that are

*The views expressed in this article represent the author's personal opinions and do not necessarily reflect the views of the Deutsche Bundesbank or its staff.

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considered to play an important role for labor market fluctuations. These shocks include a technology shock, a monetary policy shock, and a fiscal policy shock.[1]

In Germany, the number of unemployed workers fluctuates by approximately 30,000 each month.[2] The underlying worker flows are about 20 times larger and challenge both policymakers and theoretical approaches. Labeled as the Shimer (2005) puzzle, it is well known that the empirical evidence on labor market fluctuations cannot be replicated by the canonical search and matching model. Consequently, a number of papers have stated various shortcomings of the standard model, most prominently the assumption of an exogenous separation rate.

Several studies demonstrate the relevance of both the job-finding rate and the separation rate to account for country-specific unemployment fluctuations. However, those studies are mainly based on unconditional analyses that provide only an overall picture of the prevalent margin of unemployment changes. Therefore, more recent studies emphasize the importance of switching to conditional analyses on shocks [see, e.g., Balleer (2012), Canova et al. (2013)].

We disentangle different structural shocks to inspect whether the worker reallocation process depends on the underlying shock or whether it is constant across shocks. In addition, some studies criticize the focus on productivity shocks in the search and matching literature [see, e.g., Barnichon (2007)]. Accordingly, we overcome the single-shock assumption and enrich the discussion on the sources of unemployment dynamics by specifying demand-side impulses. However, we do not model the whole demand side of the economy but evaluate the role of technology shocks under the consideration of two specific demand shocks, i.e., a monetary policy shock and a fiscal policy shock.

The analysis of a technology shock corresponds to the standard search and matching model where changes in productivity are seen as the central source of unemployment dynamics. The empirical evidence on unemployment responses, however, is ambiguous. For example, Canova et al. (2013) find Schumpeterian features of neutral technology shocks in the United States, i.e., unemployment increases after a positive technology shock. This observation clearly counters the traditional view in the search and matching literature in which positive technology shocks are assumed to reduce unemployment.

The analysis of policy shocks addresses the question of the usefulness of discretionary policy interventions for controlling unemployment dynamics. Although the focus has often been on the effects of monetary policy, the interest in fiscal policy shocks has revived. The recent financial crisis has shown that conventional monetary policy measures are limited when interest rates are low. Despite wide skepticism about the effects of fiscal policy, it is argued that governments would have been better able to fight the crisis if they had been able to adopt a more expansionary fiscal stance [see Blanchard et al. (2010)]. In addition, for Germany as a member state of the European Economic and Monetary Union (EMU), decisions on monetary policy are made on a supra-national level. Because those decisions may not necessarily reflect the domestic situation, fiscal policy may be more relevant for stabilizing national unemployment fluctuations.

Our analysis is related to several studies on the worker reallocation process in the United States. For example, Braun et al. (2009) analyze the responses of labor market variables to different types of shocks. The authors find qualitatively similar results across shocks, where the responses of the job-finding rate determine unemployment changes. Demand shocks induce less persistent effects compared to supply shocks, but the demand shocks appear to be more important. When directly comparing technology and monetary policy shocks, Braun et al. (2009) identify a higher contribution of monetary policy shocks. Also related to our study is that of Fujita (2011), who shows that the fast response of the separation rate and a hump-shaped behavior of the job-finding rate are robust features with respect to several specifications.

Although the worker reallocation process in the United States seems to be independent of the underlying type of shock, our results show interesting differences for Germany. Most notably, the job-finding rate is the prevalent margin after a technology shock and a monetary policy shock, whereas the separation rate appears to be the driving force after a fiscal policy shock. Endogenizing the separation rate in theoretical labor market models thus would provide a value added particularly for fiscal policy analyses. In addition, technology shocks are relatively important for variations in the transition rates, though they cannot explain the high volatilities on the German labor market. The consideration of policy shocks points toward fiscal interventions as a promising instrument for controlling unemployment dynamics, but with several limitations.

Given our general approach, this study also serves as a starting point for further analyses on the conditional patterns of unemployment dynamics in Germany. In an application of Nordmeier et al. (2016), for example, a positive trade shock is shown to lower unemployment through a drop in the separation rate as expanding firms absorb workers at contracting firms job to job.

The paper is structured as follows: In Section 2, we review stylized unemployment dynamics from a standard New Keynesian (NK) business cycle model for reference purposes. Section 3 describes our data on German worker flows. Section 4 outlines the empirical approach, including the model specification and the estimation procedure. The results are presented in Section 5. Section 6 provides a subsample analysis and Section 7 concludes.

2. A NEW KEYNESIAN REFERENCE MODEL

As a reference point for our empirical analysis, we first derive unemployment dynamics from a standard NK model with labor market frictions. Though the NK model basically displays a macroeconomic analyzing tool for the monetary policy transmission mechanism in the presence of price rigidities, its flexible setup allows analyzing various types of aggregate shocks. In addition, it has become common practice to incorporate a standard search and matching approach into the NK model to address imperfections in the labor market [see, e.g., Walsh (2005), Blanchard and Gali (2008), Thomas (2008)]. Accordingly, this framework enables us to derive stylized labor market reactions to the aggregate shocks of interest and to discuss the empirical patterns of unemployment dynamics in Germany against a theoretical background.

2.1. Model Setup

The basic NK model represents the macroeconomic framework by means of three core equations. First, it uses an Euler equation as aggregate demand relationship that is derived from intertemporal utility maximization of private households. Households are assumed to maximize lifetime utility by consuming a bundle of differentiated products and holding money. Second, the NK model consists of a Phillips curve that displays profit maximization of monopolistically competitive firms and thus represents aggregate supply. Firms maximize profits by setting their prices and workforce. Third, the model applies a Taylor rule, which determines monetary policy. Deviations of actual inflation from its target value and output fluctuations are balanced by adjusting the nominal interest rate. Market clearing is reached by assuming that all output is consumed in equilibrium.

The NK model can be linked to the search and matching approach via an aggregate production function that includes labor as an input factor. The standard search and matching approach focuses on two labor market states: employment and unemployment. It basically comprises three relationships determining equilibrium unemployment. First, it accounts for a job creation condition that equals expected profits and costs from posting a vacancy. The expected profits result from the net return an employed worker would produce on the job, corrected by the risk of an adverse shock that destroys the occupied position, whereas the expected costs depend on search costs and the job filling probability. Second, the search and matching approach covers the Nash bargaining between firms and workers in a wage equation. After a successful match, a firm and a worker constitute a bilateral monopoly because continuing searching would imply further search costs for both sides, and the monopoly rent is distributed according to the bargaining power of the worker. Third, the search and matching approach relies on a matching function that accounts for labor market frictions in a single relation and gives the number of job matches as function of the stocks of unemployment and vacancies.[3] The matching function is a key to explain unemployment dynamics in the standard approach as the job separation process is modeled exogenously.

2.2. Simulation and Impulse Responses

For the model simulation, we rely on the model setup of Krause and Lubik (2007) and parameterize it on a quarterly basis (see Appendix B for the model equations and Tables B.1 and B.2 for the model variables and parameters, respectively). The exogenous job separation rate is set to 3% per quarter, given the labor market data for Germany (see Section 3). The remaining labor market parameters are chosen to match existing evidence for and institutional features of the German labor market, whereas other (deep) parameters are consistent with standard values. The structural shocks of interest enter the model equation as it is common in the literature: (a) the technology shock is assumed to follow a first-order autoregressive process determining the technology parameter in the aggregate production function, (b) the monetary policy shock enhances the Taylor rule by a discretionary policy component, and (c) the fiscal policy shock extends the Euler equation as an additional demand impulse via the residual.[4] The size of the structural shocks is set to unity.

Figure 1 shows the model-based unemployment dynamics in response to the shocks as percentage deviations from the steady state. The job-finding rate reacts immediately via the matching function as the aggregate shocks lead to a change in the job creation condition and thus to a change in the number of vacancies posted. Unemployment adjusts with a time lag according to the time structure underlying the model. The change in unemployment shows the net effect of the worker reallocation process at the end of the previous period and then feeds back through the matching function. This process continues until the labor market returns to equilibrium.

Though the standard parameterization of the reference model provides us with very stylized impulse responses, some important differences between the shock-induced unemployment dynamics appear. Following a positive technology shock, the job-finding rate goes up and then gradually returns to its baseline level. The unemployment reaction first builds up and reaches its peak effect after two quarters. Due to the high persistence of the technology shock, however, both labor market variables do not reach their equilibrium values within the simulation period. The reaction patterns to the policy shocks (inversely) resemble each other, but the magnitude of the effects is different. Higher government spending completely shows up in higher demand, whereas an increase in the interest rate does not, due to the consumption smoothing behavior of private households. The transmission of the policy shocks to the labor market via production proceeds accordingly. In the case of the job-finding rate, the effect of the fiscal policy shock is considerably larger than that of a technology shock, but it is rather short-lived as well as that of the monetary policy shock. Although the job-finding rate shows only a one-off reaction to the policy shocks, the adjustment process of unemployment takes some more periods according to its law of motion.

In general, the adjustment processes on the labor market seem to follow the persistence of the implemented shocks. Besides the lack of a propagation mechanism, the reference model does not produce an amplification effect as the responses are lower than the impulses, reflecting the observation of Shimer (2005). Given the stylized unemployment dynamics from the theoretical reference model, the crucial question is, however, whether the empirical counterparts mirror those conditional patterns. In case the empirical impulse responses to those standard shocks deviate substantially from the model predictions, this would give important indications on how to adjust a reference model for the German labor market to provide a suitable tool for labor market analyses.

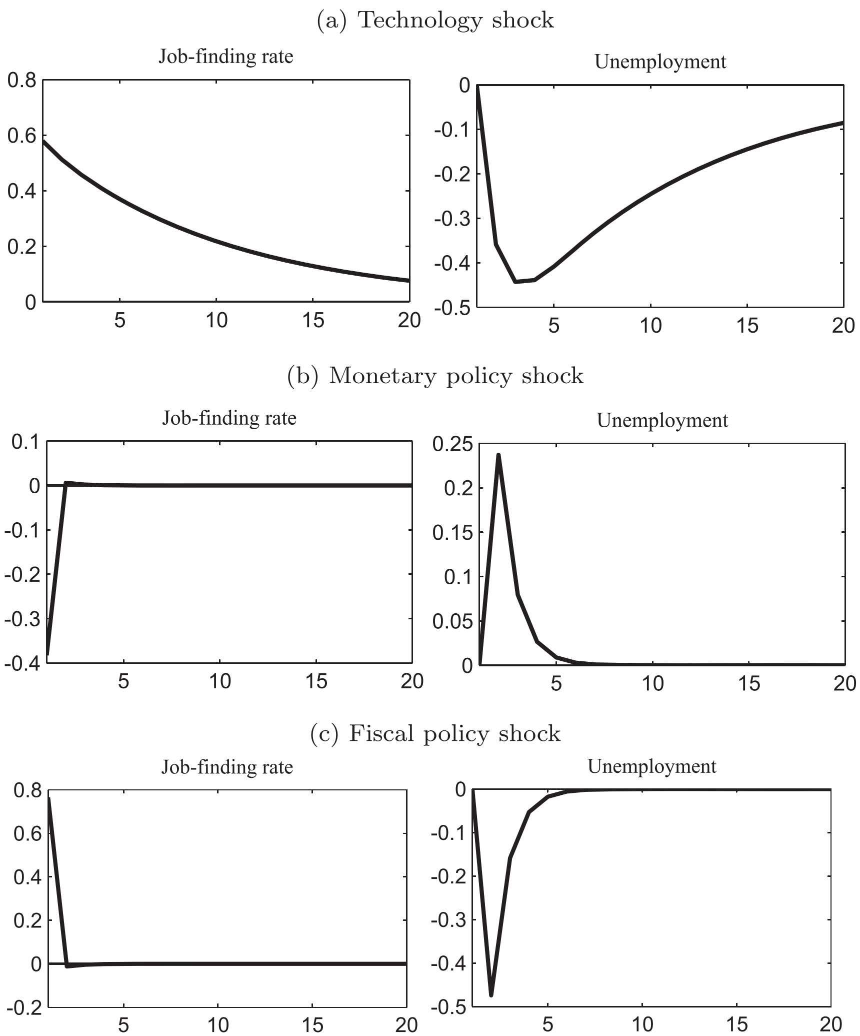

FIGURE 1. Stylized responses from an NK reference model. Impulse responses to a 1% increase in (a) productivity, (b) the interest rate, and (c) government spending. The abscissa accounts for the quarters after an impulse.

Recall that the worker reallocation process in the United States has been found to be similar across shocks. There, the hump-shaped behavior of the job-finding rate dominates the sharp responses of the separation rate, which, in turn, explains the conditional patterns of labor market stock variables [see Ravn and Simonelli (2008), Braun et al. (2009), Fujita (2011)]. Accordingly, a different adjustment process in Germany would also highlight structural differences between the United States and Germany.

3. DATA DESCRIPTION

Although we use official data to specify the structural shocks of interest in our empirical approach, we apply worker flows that are generated from the Sample of Integrated Labor Market Biographies (SIAB). The SIAB is a 2% random sample of all German residents who are registered by the Federal Employment Agency (*Bundesagentur für Arbeit*) for the administration of the unemployment insurance and benefit systems. In contrast to survey data, the administrative data face neither sample attrition nor sample rotation problems and provide individuals' labor market status on a daily basis, which is important to measure worker flows without a time aggregation bias.[5]

The administrative dataset is based on notifications on unemployment benefit receipt, but it allows us to consider those workers who are marginally attached to the labor market.[6] Our definition of unemployment therefore follows the nonemployment proxy as shown in Nordmeier (2014). The nonemployment proxy, which has been introduced by Fitzenberger and Wilke (2010), considers all nonemployment periods after an employment period, when at least one benefit receipt notification is available. Because the nonemployment proxy includes both unemployment periods with benefit receipt and unemployment periods without benefit receipt, it ensures that a high-frequency measurement of worker flows does not fail to capture relevant labor market transitions.

Given the notifications on employment subject to social security and the relatively broad measure of unemployment, we focus on a two-state environment as in the theoretical reference model. The transitions between employment and unemployment are defined by their underlying transition hazard rates, because these rates are interpreted as the driving forces of unemployment dynamics. Accordingly, the monthly job-finding rate (f) and separation rate (s) satisfy

$$f_t = \frac{(\sum_{s=1}^{S} UE_s)_t}{U_{t-1}} \qquad \text{and} \qquad s_t = \frac{(\sum_{s=1}^{S} EU_s)_t}{E_{t-1}}, \tag{1}$$

where t denotes the 10th day of a month and S denotes the number of days since the 10th day of the previous month. To account for a structural break due to the German reunification, the time series are backward adjusted using overlapping information for West Germany and the whole of Germany in 1993. Accordingly, the data for West Germany are adjusted via a constant level shift, and our time series consistently refer to reunified Germany (though the dynamics before 1993 are based on West German developments). The transition rates are then adjusted for seasonality and represented by their quarterly averages. The latter is necessary to obtain data at the same frequency as the official data that we use to specify the structural shocks [see Nordmeier (2014), for further details on the labor market data].

Figure 2 shows the transition rates during the sample period from 1981 to 2007. The job-finding rate declines from over 10% to approximately 5%. Thus, the average unemployment duration between two socially secured jobs has increased from

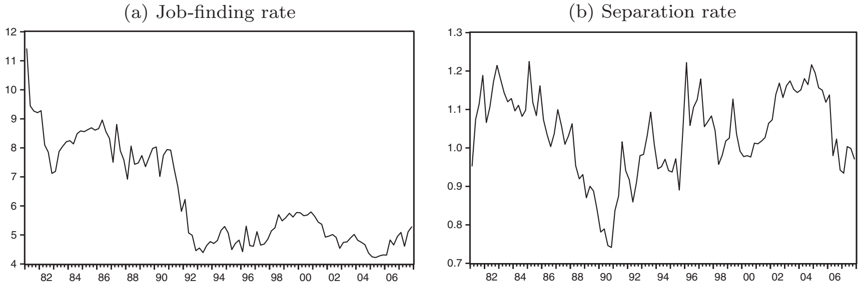

FIGURE 2. Transition rates. Quarterly averages of monthly data. (a) Job-finding rate. (b) Separation rate.

under one year to almost two years. This development, in turn, implies a substantial increase in long-term unemployment particularly in the 1980s and early 1990s. The separation rate fluctuates around 1% throughout the sample period. Hence, a job that is subject to social security lasts, on average, approximately eight years. In addition, the transition rates display different movements on business cycle frequency. Although the job-finding rate adjusts quite gradually, the separation rate depicts relatively sharp variations. The latter holds, for example, for the drop in the late 1980s (which does not result from the statistical break at the German reunification).

Business cycle statistics of the transition rates are presented in Table 1. The standard deviations indicate that the job-finding rate is more volatile than the separation rate: In the full sample, the standard deviation of the job-finding rate is 8.0% and that of the separation rate amounts to 6.4%. We also consider the descriptive statistics in the time period from 1993 onward to address changes in the economic development after the German reunification [see, e.g., Smolny (2012)]. In the subsample, the volatilities are lower. In relation to business cycle indicators, however, the transition rates appear to be more volatile in the postreunification period as the standard deviations of output, productivity, and unemployment decrease more strongly after the reunification. Moreover, the volatility ratios with respect to productivity are striking, regardless of the sample period. With such ratios of 12–15 and 10–13, respectively, German job-finding and separation rates also appear to be more volatile than U.S. transition rates.[7] Against the background of theoretical approaches, the relatively large volatility ratios with respect to productivity can be interpreted differently. On the one hand, productivity shocks could have a remarkably strong amplification effect on the German labor market, which would ask for an in-depth analysis of the transmission mechanism. On the other hand, the large volatility ratio may also indicate that productivity shocks only account for a fraction of German labor market fluctuations, which motivates a closer look at demand shocks, such as policy shocks.

The autocorrelation coefficients corroborate the observation from Figure 2 that the cyclical component of the job-finding rate is more persistent than that of the

TABLE 1. Business cycle statistics of transition rates

	Job-finding rate		Separation rate	
	Full sample	Sub-sample	Full sample	Sub-sample
Standard deviation	0.080	0.069	0.064	0.062
Relative to output	6.975	8.379	5.632	7.519
Relative to productivity	12.213	14.560	9.861	13.065
Relative to unemployment	1.085	1.136	0.876	1.019
Autocorrelation	0.620	0.595	0.571	0.580
Relative to output	1.225	1.181	1.128	1.151
Relative to productivity	1.419	0.982	1.307	0.957
Relative to unemployment	0.697	0.663	0.642	0.649

Notes: Cyclical components computed as log deviations from the underlying HP-trend with the standard smoothing parameter of $\lambda = 1,600$. Full sample refers to the time period from 1981 to 2007 and the subsample spans from 1993 to 2007. Output denotes gross domestic product (GDP). Productivity is the ratio of GDP to total hours worked.

separation rate. In addition, the transition rates are more persistent than output, but they are less persistent than unemployment. The first relation could indicate some propagation mechanism of demand shocks on the German labor market, whereas the latter relation is well captured by the impulse responses simulated with our reference model. With respect to productivity, the ratios of the autocorrelation coefficients decline significantly over time, which again may indicate that the role of productivity shocks has changed. Nevertheless, those business cycle statistics only describe the unconditional patterns of unemployment dynamics.

4. EMPIRICAL MODEL

We employ an SVAR model to analyze labor market fluctuations in a framework that requires a minimum of theoretical assumptions. This model framework thus enables us to address several ongoing discussions concerning the sources and patterns of unemployment dynamics as well as the prediction of the a priori specified NK reference model.

Our empirical approach proceeds as follows. First, we specify the VAR model and identify the structural shocks of interest. These shocks include a technology shock, a monetary policy shock, and a fiscal policy shock. Then, we describe our estimation procedure and derive the conditional unemployment response.

4.1. VAR Specification

We consider the following reduced-form VAR model:

$$y_t = \mu + A(L)y_{t-1} + \nu_t, \tag{2}$$

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where y_t is a vector of the endogenous variables, μ denotes a vector of constants, $A(L)$ is a lag polynomial of order p, and ν_t captures the residuals. In our benchmark specification, the included variables are changes in government spending (Δg_t), changes in labor productivity (Δa_t), the separation rate (s_t), the job-finding rate (f_t), and the interest rate (r_t) (see Table A.1 in Appendix A for exact definitions of the variables). The ordering of the variables may support the identifying restrictions toward a nearly triangular identification scheme.

The use of first differences follows from unit root tests that are presented in Table A.2. The augmented Dickey–Fuller (ADF) test indicates a nonstationary behavior of government spending and productivity. However, we do not impose the nonstationarity assumption on the job-finding and separation rates but leave it to the system estimation to identify a unit root or not. This approach has the advantage of allowing a flexible decision. In the case of nonstationarity, the VAR model would still be consistently estimated [see, e.g., Sims et al. (1990)].

4.2. Identification of Shocks

Because the innovations ν_t from a reduced-form VAR are typically correlated, interpreting them as structural shocks would be misleading. Therefore, we need to impose identifying restrictions on the reduced-form residuals, which allow us to disentangle structural shocks in the variables. To that end, we include a matrix B that relates the structural shocks to the reduced-form innovations

$$\nu_t = B\epsilon_t, \tag{3}$$

where $\epsilon_t \sim (0, \Sigma_\epsilon)$ summarizes the structural shocks and B describes the immediate effects of the shocks on the variables y_t. The structural shocks are assumed to be orthogonal with unit variance, i.e., $\Sigma_\epsilon = E(\epsilon_t, \epsilon_t') = I$, following the convention in the literature.

Our aim is to provide evidence on unemployment dynamics in response to economically well-founded shocks. Therefore, we base our analysis on standard identifying restrictions from seminal contributions to the SVAR literature. In doing so, we distinguish between long-run restrictions for the technology shock and short-run restrictions for the two policy shocks. Short-run restrictions contain assumptions about contemporaneous relations between shocks and variables and are thus imposed on matrix B. In contrast, long-run restrictions are imposed on the impulse responses (see Appendix C).

The technology shock ϵ^a is identified as a neutral technology shock. According to Gali (1999), we allow only technology shocks to have a permanent impact on productivity. Thus, we assume that the unit root in productivity exclusively results from technology shocks and that the long-run effects of all other shocks are zero. However, other shocks can affect productivity temporarily through its interdependency with policy and labor market variables. Such transitory impacts can be quite substantial.

The identification of the monetary shock ϵ^r follows Christiano et al. (1996). Accordingly, the monetary authority can react to other structural shocks immediately; however, the intervention works only with a one-period time lag. Hence, the monetary shock cannot influence other variables within the same period. We further assume that the monetary authority has a direct influence on the interbank money market rate.

The fiscal policy shock describes a shock in government spending. Following Blanchard and Perotti (2002), we identify the government spending shock ϵ^g by assuming that the government reacts to other shocks only with a one-quarter implementation lag. Hence, government spending depends on its own history and on lagged values of other variables but not on unexpected movements in any other variable. Put differently, government spending is predetermined.

4.3. Estimation

The combination of short- and long-run restrictions leads to a nonrecursive structure in our SVAR model and thus prevents an ordinary least square estimation. Therefore, we estimate our model with the maximum likelihood (ML) method using the Newton algorithm [see, e.g., Lütkepohl (2005, Chap. 9.3)].

After we obtain the results of the ML estimation, we apply a residual-based bootstrap procedure and run 1,000 replications to compute confidence intervals for the impulse response functions. We also adopt the median from the empirical bootstrap distribution, because the point estimates may be biased in small samples [see also Canova et al. (2013)].

Given the bootstrapped impulse responses of the transition rates, we follow Fujita (2011) and trace the unemployment response based on the law of motion. In general, a change in unemployment is given by the sum of its in- and outflows. In our two-state environment, the unemployment response satisfies

$$\Delta u_t = -\tilde{f}_t u_{t-1} + \tilde{s}_t e_{t-1}, \tag{4}$$

where $\tilde{f}_t, \tilde{s}_t$ denote the conditional transition rates and $e_t = (1 - u_t)$.

The starting point of the law of motion is the steady-state unemployment rate:

$$u_0 = u^* = \frac{\bar{s}}{\bar{f} + \bar{s}}, \tag{5}$$

where $\bar{f}, \bar{s}$ indicate the sample average (baseline value) of the transition rates.

The conditional developments of the job-finding and separation rates are received by transforming their impulse responses ψ_e into levels:

$$\tilde{f}_t = \bar{f} + \psi^f_{e,t} \qquad \text{and} \qquad \tilde{s}_t = \bar{s} + \psi^s_{e,t}, \tag{6}$$

where the sample averages $\bar{f}, \bar{s}$ again represent the baseline value and $e \in [\epsilon^a, \epsilon^g, \epsilon^i]$ describes the structural shock of interest.

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This procedure neglects any flows in and out of the labor force and thus provides the *pure* response of the unemployment rate that arises from the worker reallocation process within the labor force.

5. RESULTS

Our benchmark results are based on a lag order of $p = 2$. The choice of the lag order follows different selection criteria (see Table A.3). Considering the variation along with the maximum number of lags, the chosen lag structure satisfies most criteria.

In what follows, we present the conditional worker reallocation process and the corresponding unemployment adjustment as obtained by the impulse responses. The resulting patterns can be compared to the stylized unemployment dynamics from the NK reference model. Subsequently, we decompose the variance of the forecast errors and discuss the importance of the different shocks for the transition rates.

5.1. Impulse Responses

Impulse responses illustrate the dynamic reaction of a variable to a structural shock. The impulses are normalized to a unit increase in the underlying variable. The responses of the labor market variables are presented in percentage points; Table A.4 gives the baseline values.

Technology shock. Figure 3 shows the dynamic responses to a technology shock. A positive technology shock leads to an increase in the job-finding rate and a decline in the separation rate. Accordingly, the unemployment rate goes down. The response of the job-finding rate is significant for four quarters, whereas the response of the separation rate is only borderline significant. Hence, the technology shock appears to work primarily along the job-finding margin. This result corresponds to the standard setup of the search and matching model, where the transmission to unemployment is captured by a matching function. It also reproduces the stylized adjustment pattern from the NK reference model. Nevertheless, the separation rate does demonstrate a reaction that may support the postulation of an endogenous separation margin in theoretical approaches.

Moreover, the reduction in the unemployment rate is in line both with the NK reference model and the traditional view of the Real Business Cycle (RBC) theory, which has strongly influenced the search and matching approach.[8] Thereby, a positive productivity shock raises the expected profits from a match such that firms will post more vacancies. Because unemployment is predetermined, the rise in vacancies leads to higher market tightness and, according to the matching function, a higher job-finding rate. The higher job-finding rate, in turn, reduces unemployment. The fall in unemployment counters the increased job-finding rate

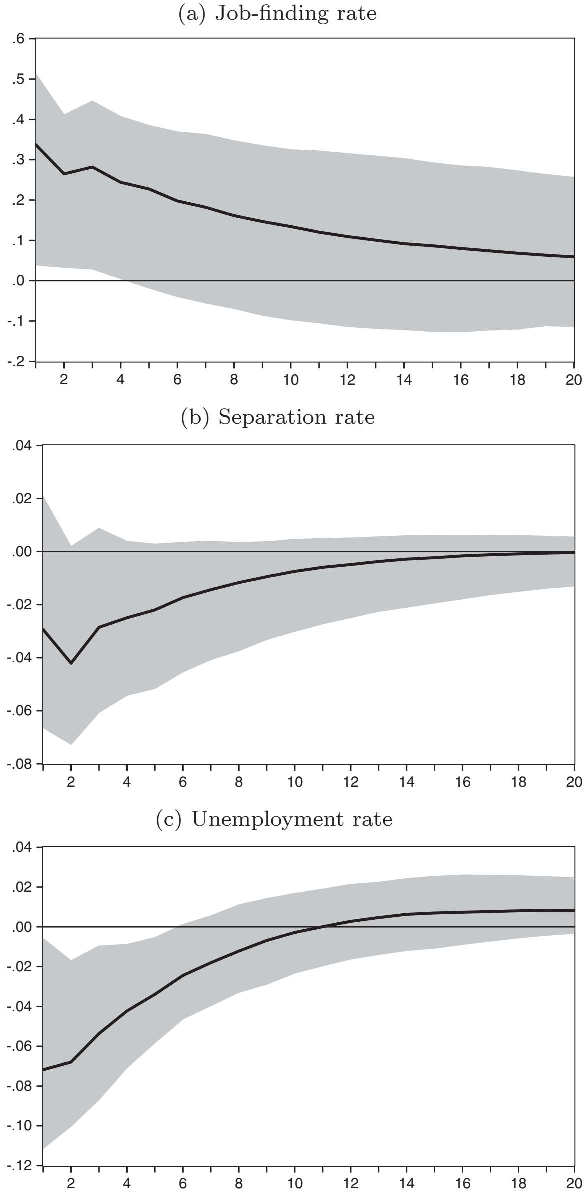

FIGURE 3. Responses to a technology shock. Impulse responses to a one-off increase in productivity. The abscissa accounts for the quarters after an impulse. The black line shows the median from bootstrapping, and the gray area demonstrates the 90% confidence interval. Benchmark sample: 1981–2007. (a) Job-finding rate. (b) Separation rate. (c) Unemployment rate.

via the matching function in subsequent periods. Finally, the variables gradually adjust to their baseline values after a one-off increase in productivity.[9]

In terms of magnitude, the unemployment rate shows a relatively resilient response, as predicted by the NK reference model. A 1% increase in productivity leads to a 0.07 percentage point reduction of unemployment, which is 0.5% of the baseline value. In contrast, the transition rates react more sensitively to a technology shock. The impact effects amount to 5.4% in the case of the job-finding rate and to 2.8% in the case of the separation rate.[10] Considering that a 1% increase in productivity is of plausible magnitude,[11] the technology shock thus fails to account for the unconditional volatilities on the German labor market. This observation, in turn, reinforces the critique on the single-shock assumption when analyzing unemployment dynamics.

Monetary policy shock. Figure 4 presents the dynamic adjustment process after a contractionary monetary policy shock. The monetary impulse triggers hump-shaped responses in the job-finding rate and the unemployment rate. The job-finding rate decreases significantly after four to nine quarters in response to a rise in the interest rate, and it then adjusts gradually to its baseline value. The behavior of the unemployment rate mirrors the response of the job-finding rate, though it is slightly smoothed by the reaction of the separation rate. The separation rate responds with a temporary drop and increases after six quarters, according to the contractionary impulse. The influence on the separation rate, however, is low and insignificant. Consequently, a monetary policy shock appears to be transmitted to unemployment through its impact on the job-finding rate. This is in line with the stylized transmission mechanism from the NK reference model, but our empirical analysis uncovers a rather high persistence of the reaction of the job-finding rate.

A certain degree of persistence can be expected considering that monetary policy shocks primarily work through aggregate investment.[12] In addition, a hump-shaped unemployment reaction after a monetary policy shock has been documented in several studies, where the velocity of the adjustment process appears to depend on the underlying labor market structure. For example, Islas-Camargo and Cortez (2011) observe a maximum effect of monetary policy shocks on Mexican unemployment after only three quarters. The authors explain this result by the existence of a large informal sector and schemes that have led to more employment flexibility. In contrast, Ravn and Simonelli (2008) find a peak effect on the U.S. unemployment after six quarters, and Alexius and Holmlund (2008) report a maximum increase in the Swedish unemployment after nine quarters. Our results for Germany show a peak effect on unemployment after seven quarters. Accordingly, a higher degree of labor market regulation seems to increase the persistence of responses to monetary policy shocks as it takes more time to meet the change in labor demand.

In line with the prediction of the NK reference model, the effects of a monetary policy shock are smaller than those of a productivity shock. A unit increase in the interest rate leads to a maximum reduction in the job-finding rate by around 0.26 percentage points, which corresponds to 4.2% of its baseline value. The maximum

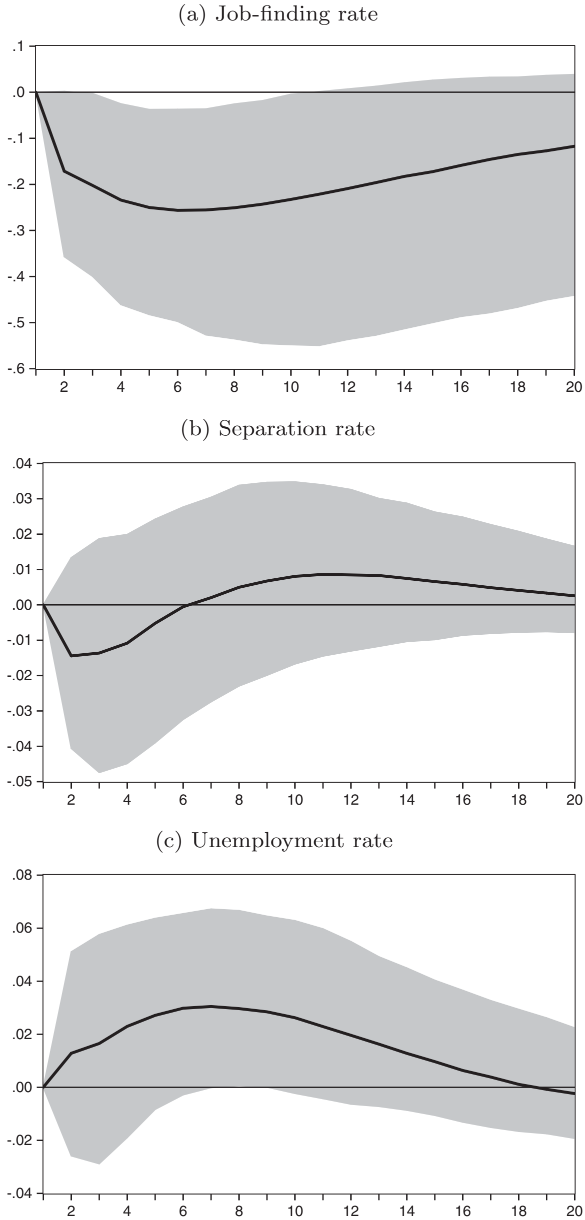

FIGURE 4. Responses to a monetary policy shock. Impulse responses to a one-off increase in the interest rate. The abscissa accounts for the quarters after an impulse. The black line shows the median from bootstrapping, and the grey area demonstrates the 90% confidence interval. Benchmark sample: 1981–2007. (a) Job-finding rate. (b) Separation rate.

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increase in the unemployment rate amounts to 0.03 percentage points, which is half the peak effect of the technology shock. Considering that the changes in key interest rates are about 0.25–0.5 percentage points, the effects appear even smaller.

Fiscal policy shock. The effects of a fiscal policy shock are plotted in Figure 5. In the impact period, the variables show the expected reactions to a rise in government spending (except for the endogenous separations response from the NK reference model view): The job-finding rate goes up (even if not significantly), the separation rate goes down, and, as a result, the unemployment rate shrinks. In contrast to the reference model results, the job-finding rate decreases after the positive impact effect and then returns sluggishly to its baseline value. At first glance, the negative side effect might indicate the Ricardian behavior, thus the general skepticism about the effects of fiscal policy. Based on the Ricardian equivalence arguments, the increase in government spending is likely to lead to a future rise in distorting taxes and thereby to lower profits. In turn, firms will reduce their labor demand, and the job-finding rate will decrease. In this light, the theoretical modeling of fiscal shocks should be reconsidered. However, as the negative effect on the job-finding rate is rather borderline significant, more evidence is needed in future research.

Except for the negative side effect on the job-finding rate, the government spending shock tends to have a short-lived influence only. A short-lived reaction is in line with the prediction of the NK reference model. In addition, a rapid adjustment process after a fiscal policy shock appears to be characteristic for the German economy. For example, Bode et al. (2006), Tenhofen et al. (2010), and Baum and Koester (2001) show short-run effects of both government spending and revenue shocks on German GDP. Instead, Ravn and Simonelli (2008) document rather hump-shaped effects of a fiscal policy shock on the U.S. output and labor market variables, with peak effects observed after three years.

Because the positive impact effect on the job-finding rate is insignificant, the fall in the unemployment rate can be mainly ascribed to the separation margin. This observation obviously challenges the NK reference model with exogenous separations. A role for separations with regard to fiscal policy was also found by Kato and Miyamoto (2013), but it stands in contrast to the conclusion of Turrini (2012). For highly regulated labor markets in OECD countries, Turrini (2012) reports a dominant role of the job-finding rate after a fiscal policy shock.[13] Thus, the result of Turrini (2012) implies that a fiscal policy shock tends to influence the average unemployment duration. Our result implies an impact on job stability, though Germany has a relatively strict employment protection. However, when firms are aware of the vanishing character of a fiscal stimulus, search frictions may hinder a temporary capacity extension along the job-finding margin and the additional demand from government spending rather prevents layoffs in the short run, whereas fixed-term contracts may help to overcome employment protection after a negative impulse.

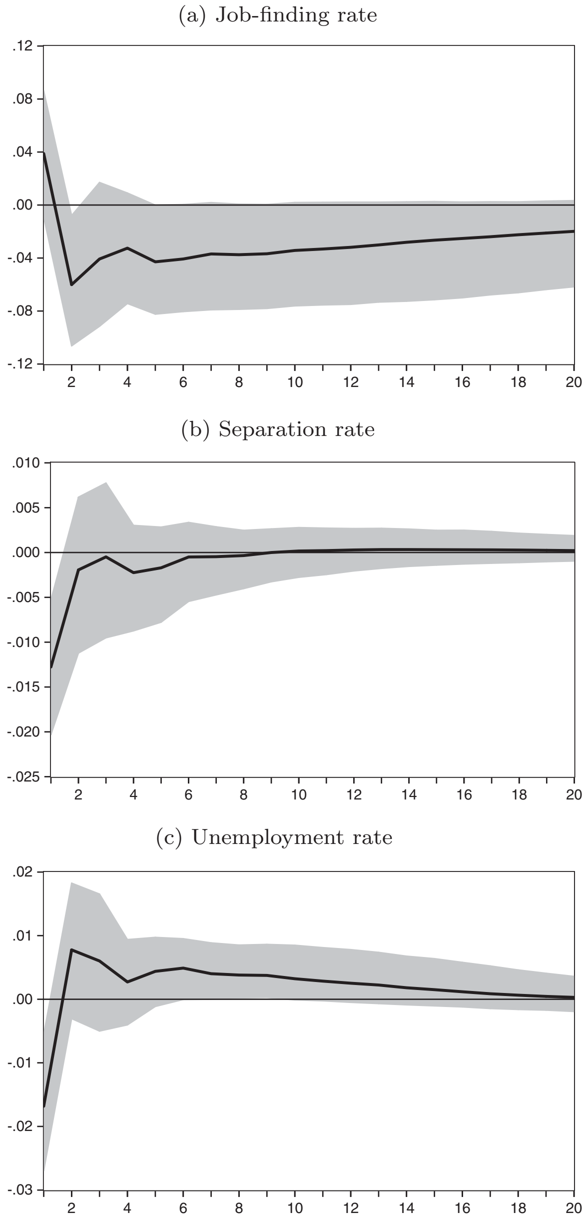

FIGURE 5. Responses to a fiscal policy shock. Impulse responses to a one-off increase in government spending. The abscissa accounts for the quarters after an impulse. The black line shows the median from bootstrapping, and the grey area demonstrates the 90% confidence interval. Benchmark sample: 1981–2007. (a) Job-finding rate. (b) Separation rate.

The size of the responses underpins the dominant role of the separation rate. On impact, a 1% increase in government spending reduces the separation rate by 0.013 percentage points and 1.2% of its baseline value. In contrast, the government spending shock raises the job-finding rate by 0.4 percentage points, which corresponds to 0.6% of the sample average. The government spending shock thus generates a small amplification effect on the separation rate but not on the job-finding rate. The impact multiplier with respect to unemployment is only 0.1%, which is also lower than that following a technology shock.[14]

To sum up, the transmission channel to unemployment responses varies significantly with the identified shocks. The job-finding rate turns out to be the driving force of unemployment responses after a technology shock and a monetary policy shock, whereas the separation rate appears to be the dominant margin in the case of a fiscal policy shock. Endogenizing the separation rate in theoretical labor market models thus would provide a value added, particularly, for fiscal policy analyses. Differences occur also in the timing and the velocity of the adjustment process. The effects of the technology shock emerge on impact and remain significant for over one year. In contrast, the monetary policy shock reaches its peak effect after 1.5 years, whereas the influence of a fiscal policy shock vanishes rapidly. These patterns are robust to several changes in the empirical setup (see Appendix D) and are in line with the stylized fact that fluctuations in the job-finding rate are more persistent than those in the separation rate.

5.2. Forecast Error Variance Decomposition

The variance decomposition of the forecast errors reveals the relevance of the structural shocks for movements in the different variables. This composition provides information over and above impulse responses, which display dynamic reactions to hypothetical shocks. The interpretation of the variance decomposition, however, is restricted to the *relative* importance of the identified shocks, because the forecast errors depend substantially on the underlying VAR system.

Table 2 gives the proportions of variations in the transition rates due to the different structural shocks. The three shocks account for approximately 40% of the forecast error variance in the job-finding rate and approximately 30% of the forecast error variance in the separation rate, which is considerable given that the shocks do not originate from the labor market but from other areas of the economy. For both transition rates, the technology shock plays a prevailing role, but the relative contribution of the technology shock compared to the two policy shocks diverges over the time horizon.

As regards the job-finding rate, the technology shock shows a maximum contribution of 41% after four periods and then decreases to 32% over the five-year forecast horizon. At the same time, the contributions of both policy shocks increase. In particular, the monetary policy shock explains up to 8%. The different developments can be related to the different shapes of the impulse responses. Although the technology shock has its maximum effect on impact, the monetary policy

TABLE 2. Forecast error variance decomposition

	Job-finding rate			Separation rate		
Forecast horizon	Technology shock	Monetary shock	Fiscal shock	Technology shock	Monetary shock	Fiscal shock
1	0.365	0.000	0.022	0.120	0.000	0.103
2	0.388	0.012	0.048	0.227	0.003	0.065
3	0.403	0.020	0.047	0.239	0.005	0.052
4	0.406	0.030	0.044	0.251	0.006	0.048
5	0.402	0.038	0.047	0.260	0.006	0.045
6	0.394	0.046	0.048	0.266	0.006	0.043
7	0.386	0.053	0.049	0.269	0.006	0.042
8	0.377	0.058	0.051	0.271	0.006	0.041
9	0.369	0.063	0.052	0.273	0.006	0.041
10	0.361	0.066	0.053	0.274	0.007	0.041
11	0.354	0.070	0.054	0.275	0.007	0.040
12	0.347	0.072	0.054	0.275	0.008	0.040
13	0.342	0.074	0.055	0.275	0.009	0.040
14	0.336	0.076	0.055	0.275	0.009	0.040
15	0.332	0.077	0.056	0.275	0.010	0.040
16	0.328	0.078	0.056	0.275	0.010	0.040
17	0.324	0.079	0.056	0.275	0.010	0.040
18	0.321	0.079	0.057	0.275	0.010	0.040
19	0.319	0.080	0.057	0.275	0.010	0.040
20	0.316	0.080	0.057	0.275	0.010	0.040

Note: Based on medians from bootstrapping.

shock reaches its peak effect on the job-finding rate only after around 1.5 years. Accordingly, the cumulative effect of the monetary policy shock arises in longer forecast horizons. The fiscal policy shock accounts for about 6% in the long run.

In contrast, the importance of the technology shock for movements in the separation rate increases steadily in shorter forecast horizons and then remains nearly unchanged. The monetary policy shock hardly contributes to fluctuations in the separation rate, whereas the fiscal policy shock matters in the short run due to its sharp impact effect. In the first forecast period, the fiscal policy shock is nearly as important as the technology shock.

Though technology shocks appear to play a dominant role in explaining labor market fluctuations, it is important to understand the effects of monetary and fiscal policy shocks: Monetary and fiscal policies are at least partly at the discretion of public institutions, whereas technology is not (or very indirectly at best). The fact that only a limited part of the labor market variation was governed by the two policy shocks, as they occurred over the sample period, does not imply that policy interventions can have no effect. The impulse responses rather show that sizeable policy shocks could definitely impact unemployment dynamics.

6. SUBSAMPLE ANALYSIS

In this section, we investigate the patterns of unemployment dynamics by focusing on reunified Germany. Because the economic development in Germany changed after the reunification, it is important to compare the worker reallocation process after the reunification with that of the full sample to give a complete picture of German unemployment dynamics. The impulse responses for the subsample from 1993 onward are plotted in Figures A.1–A.3.

Indeed, it can be seen that some responses differ from that of the full sample specification. In particular, the responses to a technology shock change their sign. The job-finding rate shows a negative response to a positive technology shock. Interestingly, this effect has also been found for the U.S. labor market. Balleer (2012) explains the "job-finding puzzle" by skill-biased technological change. Because a positive technology shock may increase the relative productivity of high-skilled to low-skilled workers, low-skilled workers will be substituted out of employment. Accordingly, the job-finding rate of low-skilled workers decreases, whereas the job-finding rate of high-skilled workers may increase. Then, if the negative effect outweighs the positive effect, the aggregate job-finding rate will decrease.

The argumentation along a substitution of low-skilled workers can be reconciled with the initial rise in the separation rate. In terms of the Schumpeterian paradigm, new technologies can cause a wave of creative destruction when existing jobs do not satisfy the new standards. The positive impact effect on the separation rate is also in line with recent evidence for the U.S. labor market. In particular, Canova et al. (2013) discuss the Schumpeterian creative destruction hypothesis for neutral technology shocks and argue that search frictions can trigger a temporary rise in unemployment. This explanation appears to match our results. After the impact period, however, the responses of the transition rates offset each other and the unemployment rate quickly adjusts to its baseline value.

The insignificance of the responses may result not only from fewer observations, but also from different features of a technology shock, i.e., traditional and Schumpeterian responses offset each other. In addition, the forecast error variance decomposition indicates that technology shocks per se have become less important after the reunification (see Table A.5). Compared to our benchmark period, the relative importance of the technology shock shrinks for fluctuations in both transition rates. In shorter forecast horizons, the relative contribution accounts for up to 30% for the job-finding rate and 19% for the separation rate. In longer forecast horizons, the contributions decrease to 26% and 16%, respectively.[15] In relation to the policy shocks, however, the technology shock still plays a prevailing role, particularly for the job-finding rate.

The monetary policy shock contributes only around 1% to the variation in the transition rates. Moreover, the responses to a monetary policy shock are low and insignificant. Particularly, the impact on the unemployment rate is close to zero as both transition rates respond negatively. The disappearing relevance of monetary policy shocks for German unemployment dynamics might be traced back to the implementation of the EMU. It seems that the national labor market has become more resilient to monetary policy shocks. At the same time, monetary policy shocks have become less important to control national unemployment dynamics.

On the contrary, the fiscal policy shock gains in importance. The contributions to the forecast errors increase by a factor of about 2–3. The shock again shows a significant impact effect on the unemployment rate through the separation margin. The response of the job-finding rate, however, turns out strictly positive, indicating that the negative side effect of preceding results is not stable. In addition, the impact multipliers with respect to both transition rates increase. Considering the baseline values for the subsample, a 1% increase in government spending raises the job-finding rate by 1.1% and reduces the separation rate by 1.8%. The fiscal multiplier with respect to unemployment is again around 0.1%.

7. CONCLUSION

Using a structural VAR approach, this paper has analyzed the conditional patterns of unemployment dynamics in Germany. For this purpose, we have specified three shocks that play a central role in business cycle research: a technology shock, a monetary policy shock, and a fiscal policy shock.

Our analysis reveals various patterns of German unemployment dynamics; i.e., the worker reallocation process is not constant across the identified shocks. In particular, the significance of the transition rates varies with the type of the shock. The impulse responses indicate a larger role of the job-finding rate after a technology shock and a monetary policy shock, whereas the separation rate appears to be the dominant margin after a fiscal policy shock. In line with the unconditional movements of the transition rates, the transmission mechanism through the job-finding margin is relatively persistent, whereas the effects along the separation margin are sharp and short-lived. Several robustness checks reinforce this clear-cut pattern.

Moreover, the discussion of the empirical results against the background of a standard reference model has made obvious the value of endogenizing separations in theoretical frameworks. Although the NK reference model has turned out to be a solid choice in many respects, our analysis shows that considering the roles of the job-finding and separation channels as well as the persistence of the effects can contribute to further improving the fit with empirical regularities. However, despite the identified adjustment patterns on the labor market, the amplification and propagation of the specified shocks remain a challenging issue as those mechanisms seem to be shock dependent as well.

The forecast error variance decomposition indicates that the three shocks under consideration account for 40% of the variations in the job-finding rate and 30% of the variations in the separation rate. Thereby, the technology shock plays a substantial role. In our full sample, the technology shock shows traditional features, i.e., an increase in productivity reduces unemployment. When we restrict our time period to reunified Germany, we also observe the Schumpeterian features, i.e., an increase in productivity leads to higher separations. In addition, the relative importance of technology shocks shrinks over time.

Monetary policy shocks seem to have become less important for unemployment dynamics in Germany. Particularly after the reunification, changes in the interest rate account for only 1% of the variations in the transition rates. The loss of importance can be reconciled with the implementation of the EMU. Nevertheless, it should be noted that those results do not concern the functioning of rule-based monetary interventions. Accordingly, the results may also indicate that the monetary authority does rarely deviate from its policy rule or that discretionary policy interventions are anticipated due to a transparent strategy.

Instead, fiscal policy shocks may be interpreted as a more promising instrument to account for unemployment dynamics. The effects of the government spending shock are significant for different specifications, and the fiscal multipliers of the transition rates have increased over time. However, our analysis also indicates several limitations. First, the effects of a government spending shock turn out to be very short-lived. Second, there are indications of a Ricardian equivalence behavior, though this observation is not stable. Third, the fiscal multipliers are of a moderate magnitude, which might fuel concerns about fiscal debt levels. Forth, the transmission of a government spending shock works primarily through the separation rate; thus, this policy measure may be less suitable to control rises in long-term unemployment triggered by other factors.

Hence, further evidence on the sources and mechanisms of labor market dynamics seems to be crucial—both for determining an optimal policy instrument and deriving a workhorse model to address the fluctuations on the German labor market. A key result from our study is that those approaches should not neglect the separation margin, particularly when shocks tend to induce less persistent patterns. This might be also an important difference to U.S. labor market analyses.

NOTES

1. The choice of structural shocks is in line with Ravn and Simonelli (2008), who analyze the effects on labor market stock variables in the United States. In contrast to Ravn and Simonelli (2008), however, we do not distinguish between neutral and investment-specific technology shocks, because we focus on the extensive margin of labor adjustment. Investment-specific technology shocks have proven to explain a major part of the dynamics of the intensive margin, i.e., hours worked [see also Fisher (2006)].

2. Average change after seasonal adjustment from 1991 to 2015. Note that the average fluctuation of unemployment has decreased to nearly 10,000 persons per month in the last years, but this development is beyond the scope of this paper.

3. Under standard assumptions, the job-finding rate is modeled as a function of labor market tightness.

4. Abstracting from any fiscal rule, discretionary government spending might be considered as deficit financed.

5. The daily information also yields a considerable advantage over the commonly used U.S. data. Shimer (2005) argues that ignoring time aggregation in monthly point-in-time measurements may

bias the job separation rate towards a countercyclical time series because the unemployment spell of a separated worker is more likely to be captured when the job-finding probability falls. Although the cyclical properties of the monthly time aggregation bias in the separation rate have turned out to be less relevant in Germany, a monthly point-in-time measurement could significantly dampen the procyclicality in the job-finding rate [see Nordmeier (2014)].

6. Jones and Riddell (1999) conclude that the conventional "job search" criterion should be supplemented by the "desire for work" criterion to measure unemployment, because the group of marginally attached workers contains important information about future employment.

7. For example, Shimer (2005) finds for the United States that the volatility of the job-finding rate is six and that of the separation rate is four times as large as the volatility of labor productivity. Albeit our data are not fully comparable with the U.S. data due to different data sources, the extent of the deviation from the U.S. volatility ratios indicates that the German labor market is at least not less volatile than the U.S. one. This observations is also in line with other studies on German worker flows, such as Gartner et al. (2012) and Jung and Kuhn (2014).

8. See, e.g., Merz (1995) for an integration of the search and matching approach in an RBC model.

9. Note that Gali (1999) suggests a rise in unemployment following a positive technology impulse. Based on an NK model setup without search and matching, he considers the intensive margin of labor and argues that firms require less labor input after a positive technology shock to produce an unchanged level of output.

10. Gartner et al. (2012) explain the high volatility of German worker flows by large hiring costs and low quit rates. Using a labor selection model with worker-firm specific productivity shocks, the authors demonstrate that those factors depress the level of the transition rates and thereby increase their sensitivity to aggregate shocks.

11. A 1% increase in productivity resembles the standard deviation of its cyclical component. For example, Gartner et al. (2012) report a standard deviation of 1.3% by computing the log deviation from the HP-trend with $\lambda = 10^5$. Using the standard smoothing parameter of $\lambda = 1600$, we observe a standard deviation of 0.7%.

12. Using a persistent shock structure or a Taylor rule with interest rate smoothing may enrich the NK reference model in a suitable way, but this extension would not address the observation that the labor market variables are more persistent than aggregate output.

13. Turrini (2012) uses an action-based variable on fiscal consolidation. Because this measure does not include cyclical movements, it can be considered exogenous.

14. The returned interest in fiscal policy has also revived the debate on fiscal multipliers. Monacelli et al. (2010) analyze fiscal multipliers with respect to labor market variables and demonstrate that wage rigidity may dampen the size of the unemployment reaction.

15. This development could also be connected to a decreasing GDP-elasticity of employment since the 1990s, as found by Klinger and Weber (2015).

16. Further evidence comes from Klinger and Weber (2016).

17. However, Fujita (2015) shows for the U.S. separation rate that aging cannot account for the whole decline that has been observed for over three decades.

18. We use the standard smoothing parameter of $\lambda = 1600$ for quarterly data.

19. The use of HP filtered data in VAR models was subject to criticism [see, e.g., Cogley and Nason (1995)]. However, our main results do not differ between first differences and HP filtered data.

20. See Statistisches Bundesamt (2012).

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APPENDIX A: FURTHER TABLES AND FIGURES

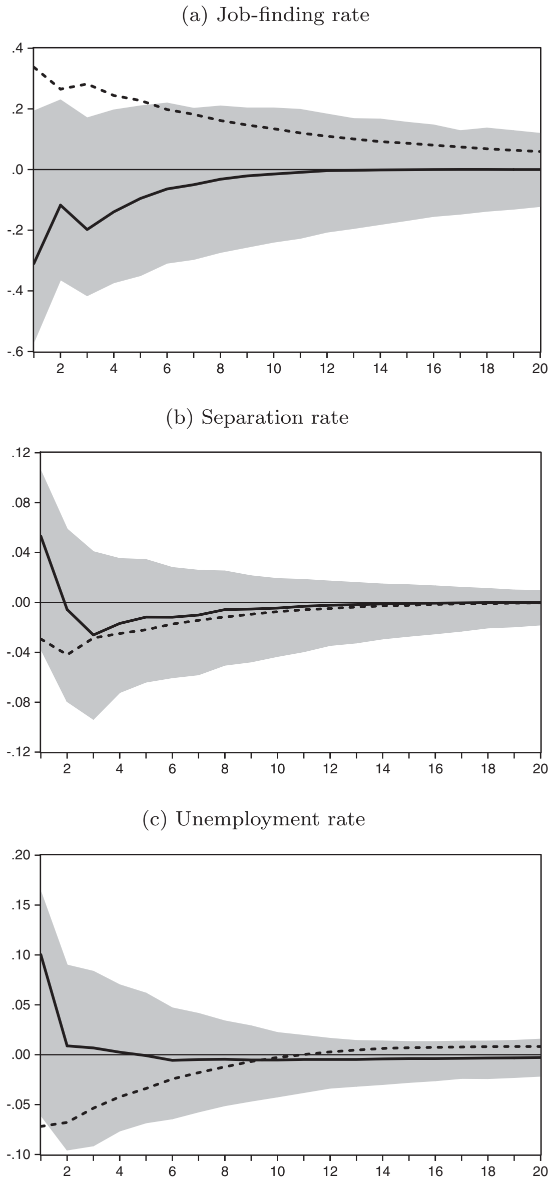

FIGURE A.1. Responses to a technology shock in the subsample. Impulse responses to a one-off increase in productivity. Solid lines including confidence intervals refer to the subsample (1993–2007) and dotted lines to the full sample (1981–2007). (a) Job-finding rate. (b) Separation rate. (c) Unemployment rate.

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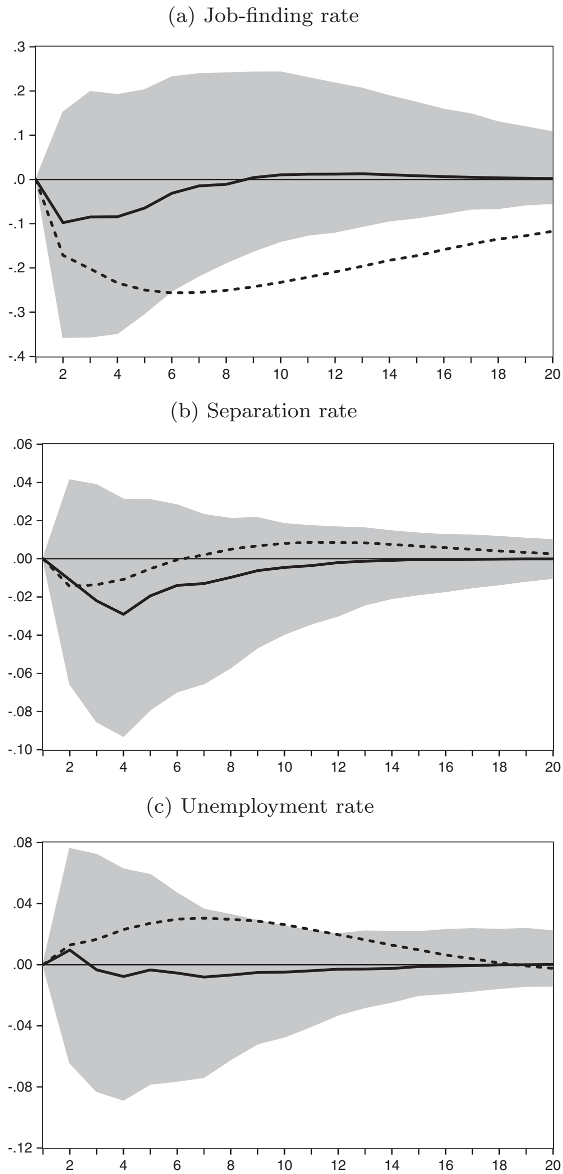

FIGURE A.2. Responses to a monetary policy shock in the subsample. Impulse responses to a one-off increase in the interest rate. Solid lines including confidence intervals refer to the subsample (1993–2007) and dotted lines to the full sample (1981–2007). (a) Job-finding rate. (b) Separation rate. (c) Unemployment rate.

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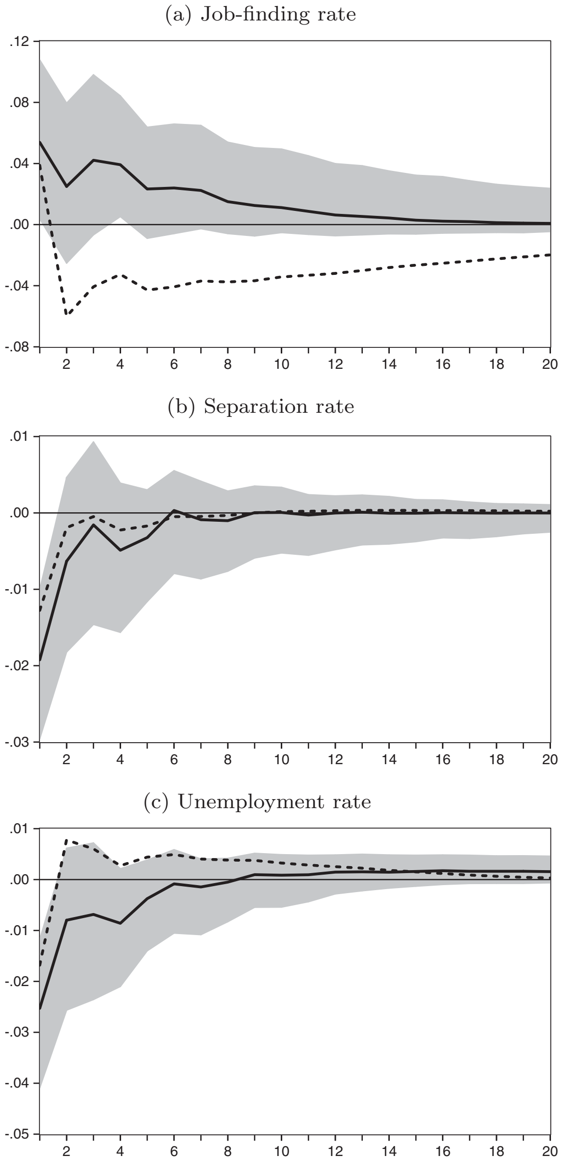

FIGURE A.3. Responses to a fiscal policy shocks in the subsample. Impulse responses to a one-off increase in government spending. Solid lines including confidence intervals refer to the subsample (1993–2007) and dotted lines to the full sample (1981–2007). (a) Job-finding rate. (b) Separation rate. (c) Unemployment rate.

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TABLE A.1. Sources and definitions of data

Time series	Definition	Source
Government spending	Sum of government consumption and government gross fixed capital formation divided by output deflator (2,000 = 100), logged	National accounts
Labor productivity	Real gross domestic product (GDP) divided by total hours worked (2,000 = 100), logged	National accounts
Job-finding rate	Transition rate from unemployment to employment (average of monthly rates based on daily transitions)	SIAB
Separation rate	Transition rate from employment to unemployment (average of monthly rates based on daily transitions)	SIAB
Interest rate	Nominal interbank money market rate (average of daily rates)	Deutsche Bundesbank

Notes: All series are seasonally adjusted using quarterly data. Western German data are linked to reunified German data in 1993 via a level shift.

TABLE A.2. Augmented Dickey–Fuller tests

	Level		First difference	
	Model specification	Test statistic	Model specification	Test statistic
Government spending	$t, c, L = 4$	-1.707	$c, L = 3$	-4.201^{***}
Productivity	$t, c, L = 4$	-2.293	$c, L = 3$	-4.452^{***}
Separation rate	$c, L = 0$	-3.031^{**}	$L = 0$	-12.062^{***}
Job-finding rate	$c, L = 1$	-2.157	$L = 0$	-13.688^{***}
Interest rate	$c, L = 1$	-3.771^{***}	$L = 0$	-5.277^{***}

Notes: The ADF regressions cover a number of lags (L) according to the Schwarz and Hannan–Quinn information criteria. Regressions may include a trend (t) and/or a constant (c). ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

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TABLE A.3. VAR lag order selection

	Selection criteria				
Maximum lag length	LR	FPE	AIC	SIC	HQ
2	2	2	2	1	1
4	4	4	4	1	1
6	4	2	4	1	2
8	4	2	2	1	1
10	4	2	2	1	1
12	4	2	12	1	1

Notes: LR = Likelihood ratio test statistic, FPE = Final prediction error, AIC = Akaike information criterion, SIC = Schwarz information criterion, HQ = Hannan–Quinn information criterion.

TABLE A.4. Baseline values

	Full sample (1981–2007)	Subsample (1993–2007)
Job-finding rate	6.247	4.960
Separation rate	1.036	1.056
Unemployment rate	14.225	17.553

Note: Values are based on the sample averages of the transition rates.

TABLE A.5. Forecast error variance decomposition in the subsample

	Job-finding rate			Separation rate		
Forecast horizon	Technology shock	Monetary shock	Fiscal shock	Technology shock	Monetary shock	Fiscal shock
1	0.300	0.000	0.076	0.192	0.000	0.210
2	0.265	0.004	0.071	0.142	0.001	0.171
3	0.294	0.005	0.087	0.147	0.004	0.143
4	0.294	0.007	0.099	0.149	0.009	0.142
5	0.289	0.007	0.100	0.149	0.011	0.141
6	0.281	0.007	0.103	0.152	0.012	0.138
7	0.276	0.007	0.106	0.154	0.013	0.137
8	0.272	0.007	0.106	0.154	0.014	0.137
9	0.269	0.007	0.107	0.155	0.014	0.136
10	0.267	0.007	0.107	0.156	0.014	0.136
11	0.265	0.007	0.107	0.156	0.014	0.136
12	0.264	0.007	0.107	0.156	0.014	0.136
13	0.263	0.007	0.107	0.156	0.014	0.136
14	0.263	0.007	0.107	0.156	0.014	0.136
15	0.262	0.007	0.107	0.156	0.014	0.136
16	0.262	0.007	0.107	0.156	0.014	0.136
17	0.262	0.007	0.107	0.156	0.014	0.136
18	0.262	0.007	0.107	0.156	0.014	0.136
19	0.262	0.007	0.107	0.156	0.014	0.136
20	0.262	0.007	0.107	0.156	0.014	0.136

Note: Based on medians from bootstrapping.

APPENDIX B: REFERENCE MODEL: EQUATIONS, VARIABLES AND PARAMETERS

The system of equations of the log-linear reference model reads as follows:

Euler equation

$$C_t = C_{t+1} - \frac{1}{\sigma} \cdot (R_t - \pi_{t+1}) + e_t^g. \quad \textbf{(B.1)}$$

Marginal utility

$$\exp(C_t)^{-\sigma} = \exp(\lambda_t). \quad \textbf{(B.2)}$$

Phillips curve

$$\begin{aligned}\epsilon \cdot [1 - \exp(\phi_t)] = 1 - \psi \cdot [\exp(\pi_t) - 1] \cdot \exp(\pi_t) + \beta \cdot \frac{\exp(\lambda_{t+1})}{\exp(\lambda_t)} \\ \cdot \psi \cdot [\exp(\pi_{t+1}) - 1] \cdot \exp(\pi_{t+1}) \cdot \frac{\exp(Y_{t+1})}{\exp(Y_t)}.\end{aligned} \quad \textbf{(B.3)}$$

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TABLE B.1. Model variables

Symbol	Description
C	Consumption
R	Interest rate
π	Inflation
Y	Output
A	Technology
λ	Lagrange multiplier w.r.t. consumption
ϕ	Lagrange multiplier w.r.t. output
v	Number of vacancies
w	Aggregate wage
m	Number of matches
f	Job-finding rate
q	Vacancy filling rate
n	Employment
u	Unemployment
θ	Labor market tightness
e^a	Technology shock
e^g	Government spending shock
e^r	Interest rate shock

Taylor rule

$$R_t - \log(R_{ss}) = \mu^{\pi} \cdot (\pi_t - \pi_{ss}) + \mu^{y} \cdot (Y_t - \log(Y_{ss})) + e_t^r. \tag{B.4}$$

Production function

$$\exp(Y_t) = \exp(A_t) \cdot \exp(n_t). \tag{B.5}$$

Technology

$$A_t = \phi^A \cdot A_{t-1} + e_t^a. \tag{B.6}$$

Job creation condition

$$\frac{\kappa}{\exp(q_t)} = \beta \cdot \frac{\exp(\lambda_{t+1})}{\exp(\lambda_t)} \cdot (1-s) \cdot \exp(\phi_{t+1}) \cdot \exp(A_{t+1}) - \exp(w_{t+1}) + \frac{\kappa}{q_{t+1}}. \tag{B.7}$$

Wage equation

$$\exp(w_t) = \nu \cdot (\exp(\phi_t) \cdot \exp(A_t) + \kappa \cdot \exp(\theta_t)) + (1-\nu) \cdot b. \tag{B.8}$$

Matching function

$$m_t = \eta \cdot u_t + (1-\eta) \cdot v_t. \tag{B.9}$$

Job-finding rate

$$\exp(f_t) = \frac{\exp(m_t)}{\exp(u_t)}. \tag{B.10}$$

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Table B.2. Model parameters

Symbol	Description	Value
β	Discount factor	0.99
σ	Risk aversion	2
ϵ	Elasticity of substitution (among varieties)	10
η	Matching elasticity w.r.t. unemployment	0.7
ν	Workers' relative bargaining power	0.8
s	Exogenous separation rate	0.03
b	Unemployment benefits	0.7
κ	Vacancy posting costs	0.2
ψ	Rotemberg parameter	50
ϕ^A	AR(1) term for technology shock	0.9
μ^π	Taylor rule: Weight on inflation	1.5
μ^y	Taylor rule: Weight on output	0.5
R_{ss}	Steady state interest rate	$1/\beta$
π_{ss}	Steady state inflation	0
Y_{ss}	Steady state output	0.85

Notes: Parameters refer to a quarterly frequency.

Vacancy filling rate

$$\exp(q_t) = \frac{\exp(m_t)}{\exp(v_t)}. \tag{B.11}$$

Law of motion of employment

$$\exp(n_{t+1}) = (1-s)\cdot\exp(n_t) + \exp(m_t). \tag{B.12}$$

Definition of unemployment

$$\exp(u_t) = 1 - \exp(n_t). \tag{B.13}$$

Labor market tightness

$$\exp(\theta_t) = \frac{\exp(v_t)}{\exp(u_t)}. \tag{B.14}$$

Resource constraint

$$\begin{aligned}\exp(C_t) = \exp(Y_t) - \exp(Y_t)\cdot\frac{\psi}{2}\cdot(\exp(\pi_t)-1)\cdot(\exp(\pi_t)-1)\\ -\kappa\cdot\exp(v_t).\end{aligned} \tag{B.15}$$

APPENDIX C: IMPOSING IDENTIFYING RESTRICTIONS

One way to demonstrate the relation between the endogenous variables y_t and the residuals ν_t is using the Wold moving average (WMA) representation

$$y_t = \sum_{i=0}^{p} \Psi_i \nu_{t-i}, \tag{C.1}$$

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where Ψ_is capture the responses to an impulse i periods ago. Substituting equation (3) gives the link to the structural shocks ϵ_t

$$y_t = \sum_{i=0}^{p} \Psi_i B \epsilon_{t-i}. \tag{C.2}$$

The sum of the impulse responses Ψ_i derives as follows:

$$\sum_{i=0}^{\infty} \Psi_i = (I_K - A_1 - A_2 - \cdots - A_p)^{-1} = \left(I_K - \sum_{i=1}^{p} A_i \right)^{-1}. \tag{C.3}$$

Then, the accumulated long-run effect of a structural shock is equal to

$$\Phi = \left(I_K - \sum_{i=1}^{p} A_i \right)^{-1} B. \tag{C.4}$$

The latter expression demonstrates the interdependence of the matrices B and Φ and thus the link of short- and long-run restrictions.

Given our identifying assumptions, the matrices B and Φ take the form

$$B = \begin{pmatrix} b_g^g & 0 & 0 & 0 & 0 \\ b_g^a & b_a^a & b_s^a & b_f^a & 0 \\ b_g^s & b_a^s & b_s^s & 0 & 0 \\ b_g^f & b_a^f & b_s^f & b_f^f & 0 \\ b_g^r & b_a^r & b_s^r & b_f^r & b_r^r \end{pmatrix} \tag{C.5}$$

and

$$\Phi = \begin{pmatrix} \phi_g^g & \phi_a^g & \phi_s^g & \phi_f^g & \phi_r^g \\ 0 & \phi_a^a & 0 & 0 & 0 \\ \phi_g^s & \phi_a^s & \phi_s^s & \phi_f^s & \phi_r^s \\ \phi_g^f & \phi_a^f & \phi_s^f & \phi_f^f & \phi_r^f \\ \phi_g^r & \phi_a^r & \phi_s^r & \phi_f^r & \phi_r^r \end{pmatrix}, \tag{C.6}$$

where $b_f^s = 0$ satisfies an arbitrary restriction to disentangle disturbances in the transition rates. This restriction, however, is without relevance for our results, because we do not investigate the disturbances in the transition rates.

APPENDIX D: ROBUSTNESS ANALYSIS

We reconsider our benchmark results along the following dimensions: First, we address some data issues, such as the indicated nonstationarity of the transition rates and their trending behavior. Then, we modify the lag length and inspect the identifying assumptions. Afterward, we examine technology shocks in a small VAR model, as was performed in previous studies.

Unit Roots. When variables appear to be integrated, it is not necessary to impose the unit root, because the estimation of a nonstationary VAR model yields consistent parameters. For an incorrect restriction, the model would be misspecified, and the estimation results are likely to be biased. However, if the restriction is correct, the estimation would gain more efficient parameters.

Because the ADF test cannot reject the null hypothesis of nonstationarity for the job-finding rate, we check our results by including the job-finding rate in first differences. We also assume a unit root in the separation rate, though the null hypothesis can be rejected at the 5% significance level. Nevertheless, redoing the unit root test by allowing for a higher lag structure, as assumed in the VAR model, points more to an integrated separation rate.[16]

The results show only slight changes. After a technology shock, the responses of the job-finding rate and unemployment rate are less significant. The response of the separation rate to a contractionary monetary policy shock turns out strictly positive, though still insignificant. Accordingly, the unemployment response becomes more significant after the monetary policy shock. These changes, however, do not affect the implications of our benchmark estimation.

Cyclical Components. An alternative procedure to treat low-frequency movements is to use a detrending method. In particular, Fernald (2007) demonstrates that VARs with long-run restrictions are sensitive to low frequencies. Even if low-frequency movements do not reflect a unit root, they can be problematic. Therefore, Fernald (2007) recommends verifying the results using alternative detrending methods.

Particularly, the job-finding rate displays a notable trend behavior. In the first part of our sample period, the job-finding rate exhibits a reduction of more than one-half of its initial value in 1981. In general, labor market dynamics may decline for several reasons. For example, changes in the composition of the labor force, such as aging, are a prominent explanation.[17] Other explanations include a fall in outside wage offers or a rise in mobility costs.

Against the background of the debate initiated by Shimer (2005), we use the Hodrick–Prescott (HP) filter to remove the trending behavior in the transition rates.[18] This specification of the transition rates may be interpreted as the underlying business cycle component.[19] The general pattern of our benchmark results is unchanged. Interestingly, the responses to a technology shock become insignificant, whereas the positive impact effect of the government spending shock on the job-finding rate turns out to be significant. This result might indicate that technology shocks are more important for low-frequency movements and that government spending shocks rather affect high-frequency variations. Moreover, the negative side effect of the fiscal policy shock on the job-finding rate nearly disappears.

Lag Length. We also re-estimate our benchmark model with a higher lag length of $p = 4$, as suggested by three selection criteria.

Allowing for a more complex adjustment process leads to more persistent responses with slightly lower impact effects. In general, the responses are less significant (which is not surprising in view of the higher number of parameters), and the negative response of the job-finding rate to a government spending shock again turns out less pronounced. Nevertheless, the key results remain unchanged.

Identifying Assumptions. So far, we have assumed that government spending does not react contemporaneously to unexpected changes in any other variable. This assumption is convincing because the government spending measure does not include transfer payments, such as unemployment benefits. Nevertheless, the government spending measure may capture other unemployment-related subsidies that are counted as public consumption.

In 2011, for example, the unemployment-related government consumption amounted to 4.39 billion euro, i.e., approximately 0.9% of overall government consumption.[20] Therefore, we relax our assumption and allow for non-zero effects of exogenous disturbances in the transition rates. Accordingly, innovations in government spending result as

$$\nu_t^g = b_{11}\epsilon_t^g + b_{13}\epsilon_t^s + b_{14}\epsilon_t^f, \tag{D.1}$$

where b_{13} and b_{14} denote the automatic responses to shocks in the transition rates. At the same time, this modification leads to an exact identification of our VAR model and thus reconsiders the overidentification issue in our benchmark specification. However, the responses of our benchmark estimation are unchanged, because the modified assumption primarily affects the shocks in the transition rates.

Small VAR. To relate our results to previous evidence, we also re-estimate our VAR model by identifying a productivity shock only, i.e., $y_t = [a_t, s_t, f_t]'$. Accordingly, we must impose two long-run restrictions to identify the technology shock and one short-run restriction to disentangle the innovations in the transition rates. Hence, this specification also satisfies an exact identification.

The results show that our benchmark estimation is robust with respect to the technology shock. In particular, the signs and magnitude of the impulse responses do not change once we exclude other variables. However, the full specification provides more insights into the sources of unemployment dynamics.