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the Beveridge Curve**

Empirical Evidence from
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Inhalt

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Labor Supply Shocks and the Beveridge Curve— Empirical Evidence from EU Enlargement*

Stefan Schiman[†]

August 2020

Abstract

Labor supply shocks can have substantial effects on the Beveridge Curve. Structural VARs with sign restrictions show that the shocks associated with the free movement of workers from Eastern Europe have temporarily increased unemployment in Austria, a major destination country, by 25% and job vacancies by 40%. The 2% increase in total employment was accompanied by a temporary decline in the employment of domestic workers. The greatest impact is seen in regions bordering on the home countries of the migrant workers. Beyond these findings the paper addresses empirical regularities of labor supply shocks that are at odds with theoretical predictions.

Keywords: labor supply shocks, Beveridge Curve, job-related migration, sign restrictions, structural VAR

JEL classification: C32, F66, J21, J63

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1 Introduction

According to the canonical search and matching model of the labor market the Beveridge Curve shifts due to reallocation shocks or, transitorily, due to aggregate activity shocks (Elsby et al., 2015).¹ Reallocation shocks are typically thought of as exogenous variations in labor market matching, either due to sectoral shifts in job creation and job destruction (structural change) or changes in matching efficiency (Abraham and Katz, 1986; Lilien, 1982). As a result, unemployment and vacancies move simultaneously in the same direction and shift the Beveridge Curve closer to or further away from the origin.² Aggregate activity shocks, on the other hand, are usually associated with movements along the Beveridge Curve. These movements may be accompanied by transitory outward shifts if vacancies respond faster to business cycle fluctuations than unemployment (Hansen, 1970). Christiano et al. (2015) show that such transitory deviations from an otherwise stable relationship can account for the movement of the US Beveridge Curve after the Great Recession.

In addition to these well-known effects, exogenous changes in the supply of labor are another independent factor that affects the position of the Beveridge Curve. The role of labor supply shocks was first addressed by Blanchard and Diamond (1989). Based on the empirical observation that the unconditional correlation between employment and the labor force is relatively high in the US, they conclude that causality runs not only from employment to the labor force (through the effects of aggregate activity shocks and reallocation shocks on participation), but that causality must run in both directions.³ They postulate a positive conditional correlation of employment and unemployment in response to labor supply shocks. With this identifying assumption they find that higher

¹The negative relationship between aggregate unemployment and vacancies is named after the British economist William Beveridge, who used it as a tool of business cycle analysis. It was formalized by Dow and Dicks-Mireaux (1958) and underwent a remarkable transformation since then (Rodenburg, 2011): After the (neo-)classic renaissance the Beveridge Curve served to distinguish structural from cyclical unemployment (Jackman et al., 1990) and eventually became a constitutive element in search and matching models of the labor market (Mortensen and Pissarides, 1999). In recent years, Beveridge Curve dynamics have gained renewed interest with respect to labor market effects of the Great Recession (cf. Furlanetto and Groshenny, 2016a and Daly et al., 2012 for the US and Hobijn and Şahin, 2013 for other developed countries).

²Furlanetto and Groshenny (2016b) show that the conditional correlation between unemployment and vacancies in response to a matching efficiency shock is positive if prices are sufficiently rigid and the shock is sufficiently persistent. Another more robust way of identification would involve data on job finding rates and job separation rates (Balakrishnan and Michelacci, 2001; Davis and Haltiwanger, 1999).

³“We are led to conclude that an exogenous increase in the labor force is probably associated with some increase in employment, that some jobs are created because new workers enter, or suppressed as existing workers leave, the labor force” (Blanchard and Diamond, 1989, p. 59).

labor supply leads to increased matching and, hence, on impact to a reduction of posted vacancies. Improved matching stimulates new hires (labor demand), such that vacancies increase in the medium run and unemployment declines. Taken together, labor supply shocks trigger a counterclockwise movement in the Beveridge space.

However, [Blanchard and Diamond \(1989\)](#) find labor supply shocks to be hardly empirically relevant for movements of the postwar US Beveridge Curve. Since then, exogenous variations in labor supply have played at best a subordinated role in the study of Beveridge Curve dynamics. This paper reemphasizes labor supply shocks and shows that they can have significant effects, in particular with respect to job-related migration.

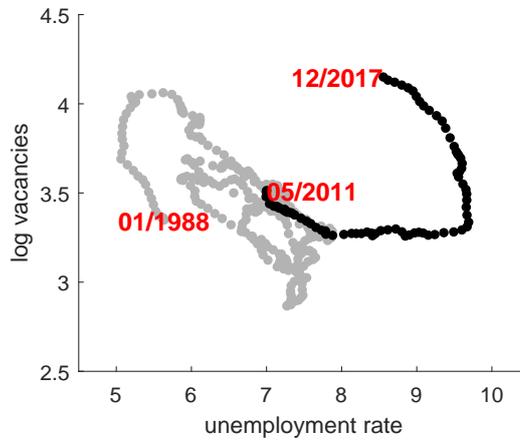


Figure 1: Beveridge Curve, 1988 – 2017

I demonstrate this with the example of Austria, a small country in central Europe, whose Beveridge Curve has shifted substantially outwards in recent years (Figure 1). This shift was preceded by a liberalization of the access to its labor market for a large group of foreign workers whose home countries had joined the European Union (see Section 2). I estimate structural vector autoregressions and identify various shocks proposed in the literature.

Historical decompositions show that the bulk of the observed shift is indeed attributable to labor supply shocks. Their superiority as compared to other competing sources of Beveridge Curve movements rests on two developments. First, the staggered increase of unemployment and vacancies only fits the pattern of labor supply shocks. It is in contrast to that of aggregate activity shocks which would require that vacancies move first. Reallocation shocks, meanwhile, usually involve a more simultaneous move-

ment of unemployment and vacancies. Secondly, the increase in unemployment went along with an increase in aggregate employment. This is an exclusive property of labor supply shocks, as these variables would correlate negatively in response to reallocation shocks and aggregate activity shocks.

The paper provides several further insights. In a regional analysis, labor supply shocks are found to be distributed unequally across regions: The closer the region is to the migrants' home countries, i.e. the more likely it is that workers will be able to commute or at least make short-term stays at home, the more intensive the shocks will be. I also find that foreign workers displace domestic workers in the short run, but that this displacement effect is only transitory and that domestic employment returns to its pre-shock level in the medium run. Furthermore, I substantiate previous empirical evidence that labor supply shocks have inflationary effects. This suggests that they entail stronger (labor) demand repercussions than predicted by theoretical models. I discuss the consequences of this result for sign restrictions and conclude that caution is needed when labor supply shocks are identified without resorting to a proper restriction of unemployment.

Related literature The paper draws from and contributes to a strand of the literature that uses vector autoregressions (VARs) identified by sign restrictions to analyze labor market dynamics. [Fujita \(2011\)](#), [Cairó et al. \(2019\)](#) and [Fontaine \(2019\)](#) identify shocks along the US Beveridge Curve to study the response of various labor market variables. [Hairault and Zhutova \(2018\)](#) investigate the relative contributions of the job-finding rate and the separation rate to unemployment fluctuations in France and the US in response to multiple structural shocks. [Benati and Lubik \(2014\)](#) combine sign and long-run restrictions to identify transitory and permanent shocks and investigate time variation in the US Beveridge Curve during the postwar period. [Mumtaz and Zanetti \(2012\)](#) use a sign restriction identification scheme to study the dynamic responses of labor input to technology shocks.

With respect to labor supply shocks, an important contribution has been made by [Foroni et al. \(2018\)](#). These authors derive sign restrictions from a fully fledged New-Keynesian macro model with search and matching frictions and apply them to VARs estimated on US data. They find that as labor supply shocks raise the number of job seekers, competition for vacancies intensifies. This makes it more difficult for existing job seekers (unemployed) to be matched to a vacancy, bolstering the stock of unemployment. On the other hand, higher supply of labor and a potentially richer variety of skills enables

firms to fill their vacancies faster, bolstering the stock of employment and dampening the stock of vacancies. The labor supply shock dampens wages and stimulates labor demand. This lifts employment further, it fosters vacancy postings and dampens the heightened level of unemployment. Again, labor supply shocks result in a counterclockwise outward movement of the Beveridge Curve.

There is also a nascent VAR literature on migration-specific labor supply shocks; important contributions include [Kiguchi and Mountford \(2019\)](#) on the US, [Furlanetto and Robstad \(2019\)](#) on Norway and [Smith and Thoenissen \(2019\)](#) on New Zealand. This is the first paper that explicitly addresses Beveridge Curve dynamics of labor supply shocks. In doing so, it draws on the case of Austria which experienced an acceleration of immigration due to the enlargement of the European Union. The analysis of regional effects is another novel contribution to the literature. Furthermore, the paper addresses the inflationary effect of labor supply shocks and discusses its consequences for identification.

Structure of the paper The analysis proceeds as follows: Section 2 provides some background information on the institutional context of the labor supply shock under investigation. Section 3 sets out the empirical model and the identification assumptions. Section 4 presents the results for impulse responses, Beveridge Curve counterfactuals, a specification that distinguishes between domestic and foreign workers and a regional analysis. It also places the findings on the Beveridge Curve in a broader context of labor market developments in Austria. Section 5 introduces an extended model and Section 6 concludes.

2 EU Enlargement and Job-Related Migration

In 2004, ten Eastern European countries joined the European Union: Poland, Hungary, the Czech Republic, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Malta and Cyprus (henceforth: EU-2004); eight of them belonged to the former Communist bloc. This constituted the most fundamental enlargement in the history of the European Union and its predecessor organizations. In 2007, Romania and Bulgaria followed (henceforth: EU-2007), in 2013 Croatia.

EU membership provided the citizens of these countries with the right of free movement of labor, a pillar of European integration. Incumbent EU countries were granted a transition period of up to seven years for opening their labor markets to citizens of the

new members states. Some enacted the provision immediately, among them the UK, where the ensuing acceleration of immigration had substantial economic and political effects (Becker and Fetzer, 2018). In Ireland, another early-adopter of labor market liberalization, job-related migration has amplified the business cycle (Lozej, 2019).

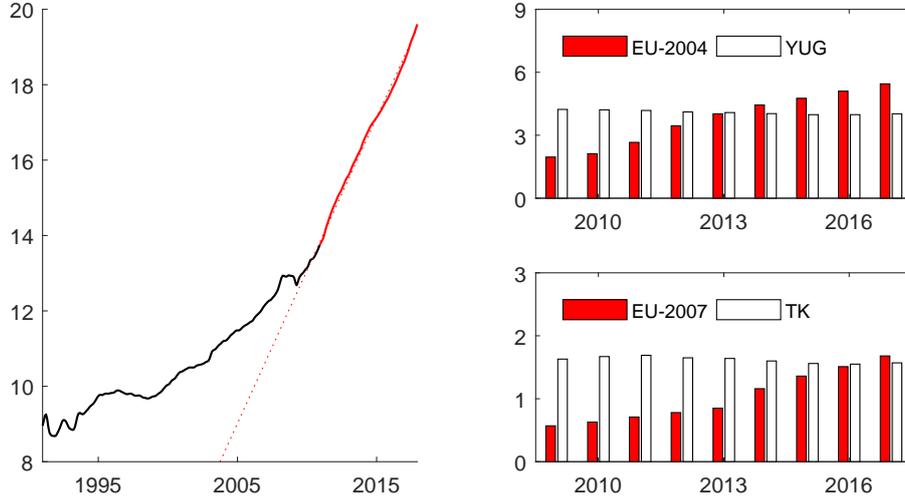


Figure 2: Share of foreign workers in % of total employment

EU-2004: Poland, Hungary, Czech Republic, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Malta, Cyprus; YUG: former Yugoslavia excl. Slovenia, Croatia; EU-2007: Romania, Bulgaria; TK: Turkey.

The number of workers from EU-2004/2007 countries surpassed the number of workers from YUG and TK, who constituted the largest non-German speaking groups of foreign workers before. Labor immigration from there started in the 1960s with “guestworker” recruitment.

In contrast, Germany and Austria exploited the maximum transition period of seven years, i.e. until May 2011 for EU-2004 countries and January 2014 for EU-2007 countries. One of the reasons for Germany and Austria to choose the maximum period was the perception that due to their geographical proximity to some of the accession countries they would be prime candidates for job-related migration. Austria was even more exposed to this risk than Germany, as its territory is closer to the accession countries than most of Germany’s territory, it shares a common border with Hungary, the Czech Republic, Slovakia and Slovenia and the income gap towards the accession countries is larger than the income gap of east Germany with e.g. adjacent Poland.

Schmieder and Weber (2018) investigate migrant employment in Austria prior and after labor market liberalization and find a substantial acceleration of job-related migration. This development is visualized in Figure 2. The left panel shows the number of

foreign workers as a share of total employment (in %). This share was increasing already in the years prior to 2011, but the increase accelerated significantly since then which can be inferred from the dotted line that extrapolates the post-2011 trend backwards. The right panel compares different groups of foreign workers. It shows that the trend acceleration of the share of foreign workers was indeed due to workers from EU-2004 and EU-2007 countries; while the share of traditional groups of foreign workers from Turkey and former Yugoslavia stagnated.

3 Empirical Model

In their seminal work on the Beveridge Curve, [Blanchard and Diamond \(1989\)](#) differentiate between two types of macroeconomic shocks: business cycle or aggregate activity shocks on the one hand and structural or reallocation shocks on the other. The former move job creation (vacancies) and job destruction (unemployment) in opposite directions: In an upturn, vacancies increase and unemployment declines. In a downturn, vacancies are reduced and unemployment rises. Reallocation, on the other hand, entails that while jobs (and vacancies) are created in certain sectors of the economy, at the same time some are lost in others (raising unemployment). This distinction enables them to roughly describe the movements in the Beveridge space: either along the Beveridge Curve (due to “aggregate activity shocks”) or shifting the Beveridge Curve (due to “reallocation shocks”). Both shocks are defined on the assumption of a constant labor force. This implies that employment, the third variable in this setup, moves in the opposite direction of unemployment.

Allowing for variations of labor supply introduces a third shock to the system: exogenous movements of labor supply. Labor supply shocks are identified on the assumption that employment and unemployment move in the same direction on impact, while the response of vacancies is undetermined. This is motivated by the following reasoning: An exogenous increase of labor supply increases employment due to improved matching opportunities and lower search time for firms. At the same time the search time of job seekers increases, which raises unemployment. The impact response of vacancies is left unrestricted, as improved matching dampens the vacancy stock while lower recruiting costs and lower wages elicit further posts. This reasoning and the assumption that labor supply shocks are the *only* shocks that move employment and unemployment in the same direction is compatible with a wide range of New-Keynesian macro models with

endogenous labor supply, like e.g. Galí et al. (2011).⁴ Labor supply may respond to aggregate activity shocks and reallocation shocks as well, but by less than employment to preserve the negative conditional correlation between employment and unemployment in response to these shocks.

$b_{ij} \in \mathbf{B}^{-1'}$	employment	unemployment	vacancies
reallocation shock	+	−	−
aggregate activity shock	+	−	+
labor supply shock	+	+	

Table 1: Impact sign restrictions, baseline model

Blanchard and Diamond (1989) assume fixed elasticities and a unique impact multiplier matrix for identification. Identification by sign restrictions is less restrictive (e.g. it does not rely on specific assumptions for employment elasticities, etc.) and, given the definitions above, straight-forward (Table 1). Let

$$\mathbf{y}_t = \mathbf{C} + \sum_{i=1}^l \mathbf{A}_i \mathbf{y}_{t-i} + \mathbf{u}_t \quad (1)$$

be the reduced-form model, where \mathbf{y}_t is a vector of endogenous variables, \mathbf{C} is a matrix of deterministic terms, \mathbf{A}_i are reduced-form parameter matrices and $\mathbf{u}_t \sim \mathcal{N}(\mathbf{0}, \Sigma_{\mathbf{u}})$ is a vector of reduced-form residuals. In the baseline specification, \mathbf{y}_t includes aggregate employment, unemployment and vacancies, which are all measured in thousands of persons.⁵ All data are in monthly frequency, seasonally adjusted and range from 1988m1 to 2017m12 (360 observations, Figure A1 in the appendix).⁶ The model is estimated with variables in levels and Bayesian techniques, employing a diffuse Normal-Wishart prior on $\mathbf{A} = [\mathbf{C}, \mathbf{A}_1, \dots, \mathbf{A}_l]$ and $\Sigma_{\mathbf{u}}$. The lag order l is set to 6.

⁴In this model, the positive conditional covariance of employment and unemployment also applies to price mark-up shocks to some extent. However, Ferroni et al. (2019) show that price mark-up shocks do not generate statistically significant dynamics.

⁵A specification containing data on domestic and foreign workers separately is presented in Subsection 4.2.

⁶The unadjusted series are accessible via the statistical databases of the Federal Reserve Bank of St. Louis (FRED) and the Organization for Economic Cooperation and Development (OECD). Level of vacancies: LMJVTTUVATM647N (FRED), LMJVTTUV (OECD); level of unemployment: LMUNRLT-TATM647N (FRED), LMUNRLTT (OECD); unemployment rate: LMUNRRTTATM156N (FRED), LMUNRRTT (OECD). The construction of the level of employment follows from the latter. Data are seasonally adjusted using the Tramo/Seats procedure, an ARIMA based seasonal adjustment method (Gómez and Maravall, 1996), and the trend cycle component is retained.

To recover orthogonal innovations \mathbf{w}_t (i.e. $\mathbf{w}_t = \mathbf{B}\mathbf{u}_t$, such that $\Sigma_{\mathbf{w}}$ is diagonal) I resort to a method that has become popular in the literature ([Rubio-Ramírez et al., 2010](#)). The structural impact multiplier matrices \mathbf{B}^{-1} are chosen as the product of the Cholesky factor of $\Sigma_{\mathbf{u}}$ and orthogonal matrices \mathbf{Q} obtained via a QR decomposition of matrices sampled from a standard Normal distribution. From the infinite set of \mathbf{Q} 's those that lead to appropriate structural models, i.e. draws with structural shocks satisfying the impact sign restrictions given in [Table 1](#), are retained. Sampling stops when five thousand appropriate draws are collected. The set of appropriate draws accounts for estimation uncertainty (by sampling \mathbf{A} and $\Sigma_{\mathbf{u}}$) and model uncertainty (by sampling \mathbf{Q} for a given pair of \mathbf{A} and $\Sigma_{\mathbf{u}}$).

4 Results

[Figure 3](#) presents impulse responses to the structural shocks over a horizon of ten years. The shocks are normalized such that they induce a positive impact response of employment. With regard to the economic interpretation of reallocation, aggregate activity and labor supply shocks, this means that the intensity of reallocation declines, aggregate activity picks up, and labor supply increases, respectively. Due to the linearity of the model, the choice of normalization does not affect the results.

The reallocation shock moves unemployment and vacancies in the same direction. The response of vacancies lasts for several years, unemployment returns sooner to its pre-shock level. The response of employment exhibits a sign reversal. This is in line with the results of [Blanchard and Diamond \(1989\)](#). A tentative explanation for this is that increased structural change entails job losses in the short run, but it is a boon for the economy in the long run. The aggregate activity shock moves unemployment and vacancies in different directions. It elicits transitory effects on all three variables, which prevail for a typical business cycle horizon of 2 – 3 years.

Labor supply shocks have a pronounced, but transitory effect on unemployment and a muted, but steady effect on employment. In line with the presumed counteracting effects, the impact response of vacancies is not clear-cut; the (vacancies dampening) effect of improved matching and the (vacancies increasing) effect of lower recruitment and labor costs coincide. In the medium run, the latter effect dominates. This behavior dovetails with the medium-run acceleration of employment and the reversal of unemployment. Taken together, it suggests that the labor supply shock elicits a significant repercussion of labor demand.

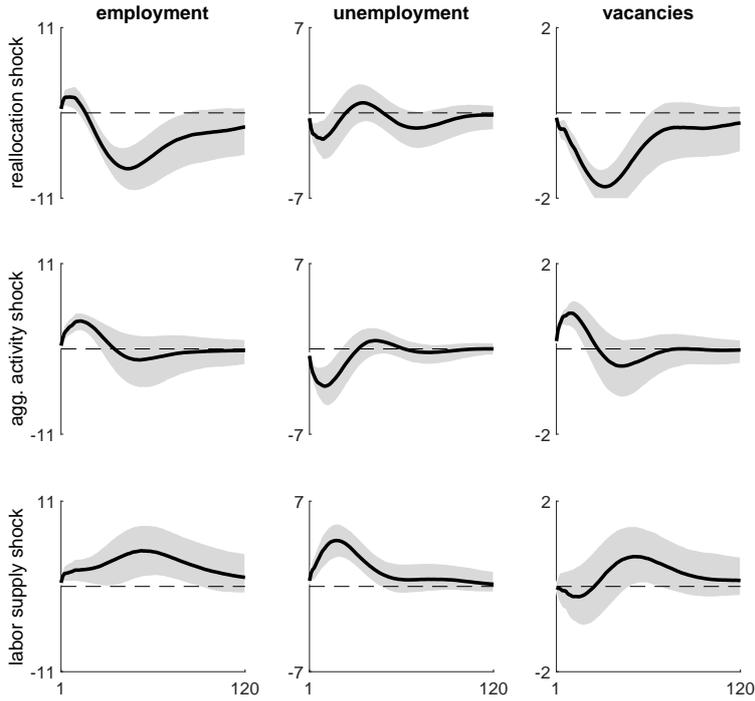


Figure 3: Impulse responses, baseline model

Point-wise medians and 68% credible sets, horizon: 10 years (120 months), unit: in thousands.

These results hold up to various specifications: to using a Minnesota prior instead of a diffuse prior, to extending the lag length to $l = 12$ and to extending the sample period back to 1960.⁷ The median impulse responses of these robustness checks are given in Figure A3 in the appendix, together with the credible sets from the baseline specification.

Point-wise medians and corresponding 68% credible sets are traditional summary measures that are not without problems when set-identification is used, as different \mathbf{B}^{-1} and, hence, different structural models are mixed. A measure that copes with this issue is the so-called “median target” proposed by Fry and Pagan (2011). It amounts to choosing

⁷The Minnesota prior shrinks the VAR estimates towards a multivariate random walk, which is a reasonable assumption for the variables at hand. The hyperparameter on prior variances of own and lagged coefficients is set to 1. The prior on the deterministic terms has mean zero and variance 100.

the structural model with impulse responses closest to the point-wise median. To make responses comparable across impulses and variables, they are standardized according to

$$\tilde{\phi}_{j \times k, t} = \frac{\phi_{j \times k, t} - \text{med}(\phi_{j \times k, t})}{\text{std}(\phi_{j \times k, 0})}, \quad (2)$$

where $\phi_{j \times k, t}$ is the response of variable j to shock k in period t , $\text{med}(\phi_{j \times k, t})$ is the point-wise median response in each period t and $\text{std}(\phi_{j \times k, 0})$ is the standard deviation of the impact responses. The draw closest to the point-wise median is the one that minimizes the sum of all squared standardized responses over the chosen horizon,

$$\min \left(\sum_{j \times k} \sum_t \tilde{\phi}_{j \times k, t}^2 \right). \quad (3)$$

Impulse responses for the median target are shown in Figure A2 in the appendix. These responses are very close to the point-wise medians and, hence, a reasonable choice in the following counterfactual exercise.

4.1 Counterfactuals

The locus in Austria's Beveridge space has moved considerably to the upper right in recent years. It did not do so immediately, however. An initial rightward movement was followed by a marked upward movement and, eventually, a shift to the upper left (Figure 1). This temporal sequencing dovetails with the estimated effects of labor supply shocks. In order to quantify these effects for the period of interest, the variables y_j at time t are decomposed into the contributions of each shock w_k in each preceding period i up to $t - 1$ and of the deterministic terms c_j ,

$$y_{j, t} \approx c_j + \sum_{i=0}^{t-1} \phi_{j \times k, i} w_{k, t-i}. \quad (4)$$

The first line of Figure 4 presents Beveridge Curve counterfactuals for the median target, i.e. the draw with impulse responses closest to the point-wise median (according to Fry and Pagan, 2011). Gray dots are historic data from 1988m1 to 2011m4, black dots from 2011m5 onwards (remember that the labor market was liberalized in 2011m5). Red dots represent counterfactual outcomes that would have prevailed, if from 2011m5 onwards only one specific shock, mentioned in the graph title, had hit the economy.

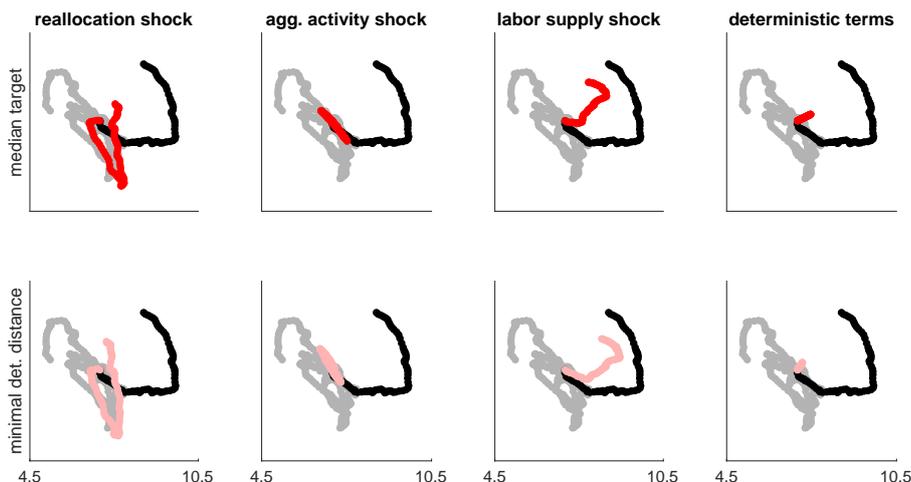


Figure 4: Beveridge Curve counterfactuals, baseline model

Gray dots: realized data up to 2011m4, black dots: realized data as of 2011m5, red dots: counterfactuals as of 2011m5 if only the shock mentioned in the title had prevailed, based on the median target draw, pink dots: counterfactuals based on the draw close to the point-wise median and with the minimal contribution of deterministic terms to movements in the Beveridge space.

Labor supply shocks account for a large fraction of the movement in the Beveridge space, with regard to the *size* as well as the *pattern* of the movement. However, the exercise is somewhat impaired by the fact that the deterministic terms of the empirical model account for a non-negligible fraction of the outward movement. Since deterministic terms are not informative about the economic forces that pulled the Beveridge Curve outwards, I instead choose a draw with impulse responses also very close to the point-wise medians (but not as close as the median target), but with a minimal contribution of deterministic terms.

To achieve this, the set of models is shrunk to a small set (1% of all draws) with impulse responses close to the point-wise medians.⁸ Out of these draws the one that minimizes the Euclidian distance of the deterministic terms' contribution to the change of the locus in the Beveridge space is chosen, i.e. $\min \sum_j (\tilde{c}_{j,2017m12} - \tilde{c}_{j,2011m5})^2$, where j includes the unemployment rate and vacancies and \tilde{c} are standardized contributions (i.e. scaled by their respective standard deviations) to establish comparability among them (impulse responses are shown in Figure A2 in the appendix). This model, which

⁸The results are the same for a set of 5% and qualitatively similar for larger sets, i.e. if less weight is put on the Fry-Pagan measure.

is presented in the second line of Figure 4 (pink dots), largely confirms the results of the median target.

It seems that the reduced impact of the deterministic term is captured by reallocation shocks, which gain relative importance in accounting for the *size* of the outward shift. The identified labor supply shock again fits the *pattern* of the realized outward shift and it is confirmed that the latter cannot be rationalized without resorting to the impact of labor supply shocks. The results hold up to the robustness checks introduced before (the corresponding counterfactuals are presented in Figure A4 in the appendix).

4.2 Foreign Workers

So far, it has been shown that a considerable share of the outward shift of the Beveridge Curve in recent years was caused by labor supply shocks. Furthermore, it was pondered that the latter might have intensified since labor market access was liberalized for certain groups of foreign workers. Since Austrian employment data contains information on the employees' citizenship it is possible to investigate this hypothesis by distinguishing labor supply shocks caused by domestic workers from labor supply shocks caused by foreign workers.⁹

$b_{ij} \in \mathbf{B}^{-1}$	employment			
	domestic	foreign	unemployment	vacancies
reallocation shock		+	–	–
aggregate activity shock		+	–	+
foreign labor supply shock		+	+	
	$< b_{32}$			
domestic labor supply shock		+	+	
	+	$< b_{41}$		

Table 2: Impact sign restrictions, 4-dimensional VAR

The identification assumption is in the vein of Furlanetto and Robstad (2019), who distinguish labor immigration shocks from domestic labor supply shocks by imposing different signs on the impact ratio of immigrants over participants. Imposing the sign on

⁹Foreign workers include all employees with non-Austrian citizenship. A shock might also capture changes in the naturalization process of the authorities, but these effects should be small. Domestic labor supply shocks capture demographic variations that are not migration-related, changes towards the attitude to wage-work, pension reforms and school reforms, such as e.g. the extension of compulsory schooling from 8 to 9 years in 1966/67.

the ratio leaves the direction of the absolute response undetermined, i.e. the employment of domestic workers might well increase in response to a supply shock of foreign workers, but the increase must be smaller than the increase of the number of foreign workers.

In this specification, employment of domestic workers and employment of foreign workers are included in place of total employment; vacancies and unemployment (containing both Austrian and non-Austrian citizens) remain unchanged. The corresponding sign restrictions are given in Table 2.

The sum of domestic and foreign workers (total employment) increases on impact in response to all shocks. The number of foreign (domestic) workers increases in response to a positive foreign (domestic) labor supply shock. The number of domestic (foreign) workers *may* increase as well, but by less than the number of foreign (domestic) workers. This restriction is equivalent to restricting the response of the ratio of foreign over domestic workers. On the other hand, the number of domestic (foreign) workers may (and will) decrease, if there are displacement effects between the two groups. However, net displacement must not exceed the size of the labor force increase provided by the labor supply shock, which seems to be a fairly reasonable restriction. For example, if a supply shock raises the number of foreign workers by 5.000, the stock of domestic workers must not decline by more than 5.000. This restriction is necessary to ensure that total employment responds positively to labor supply shocks and, hence, to uniquely distinguish labor supply shocks from reallocation shocks. Hence, in response to a foreign (domestic) labor supply shock, domestic (foreign) employment changes by less than foreign (domestic) employment *in absolute terms*.

The distinction between domestic and foreign workers enriches the findings of the baseline model by several aspects (Figure 5). The response of total employment to foreign labor supply shocks is muted, as the number of foreign workers rises while employment of domestic workers decreases. This means that supply shocks by foreign workers exert displacement effects on domestic workers on impact. But this effect is only transitory, as the number of domestic workers returns to its pre-shock level in the medium run (i.e. after several months to years). For domestic labor supply shocks, on the other hand, the positive effect on total employment stems from the increase of the number of domestic workers. Domestic labor supply shocks have hardly any effects on foreign workers.

The two labor supply shocks are also different with respect to their effects on unemployment. Foreign worker shocks have a much more pronounced and more persistent effect. The rise of unemployment is transitory but, for most draws, it is not entirely reversed.

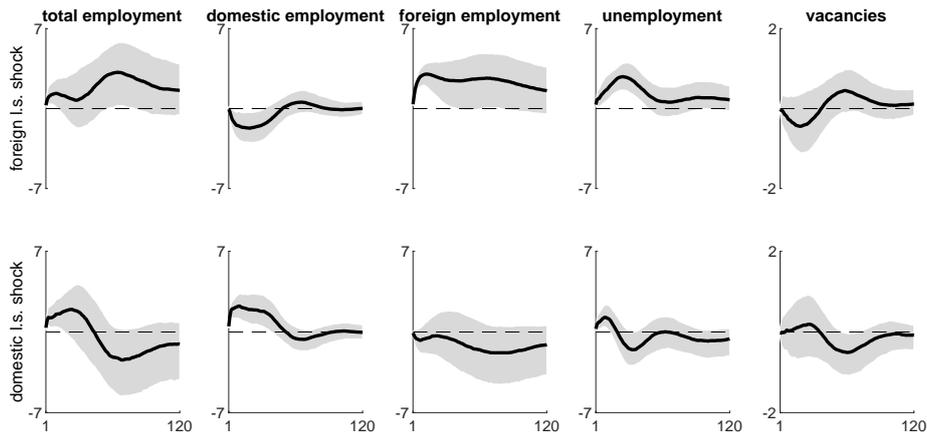


Figure 5: Impulse responses to different labor supply shocks

Point-wise medians and 68% credible sets, horizon: 10 years (120 months), unit: in thousands.

There is also some tentative additional information with respect to vacancies. Their response to foreign labor supply shocks is similar to the response within the baseline 3-dimensional specification, while the response of vacancies to domestic labor supply shocks follows a different pattern. So, the response of vacancies in the 3-dimensional model seems to be driven by foreign workers.

This result might be due to the characteristic and composition of *reported* vacancies. Vacancies are chronically under-reported and they are more likely reported for standardized jobs with lower skill requirements.¹⁰ As labor immigrants are lower skilled than domestic workers on average, foreign job seekers might be more likely matched to reported vacancies, while domestic job seekers might be more likely matched to non-reported vacancies. This observation is corroborated by [Schmieder and Weber \(2018\)](#) who, based on Austrian social security data, find that the liberalization of labor market access did not only accelerate immigration but that it led to a “*shift in the composition of migrant workers toward lower-qualified and younger groups*” (p. 114).

¹⁰Since 2009, the National Statistical Institute has been conducting company surveys to obtain a more complete picture of all vacancies. Less than two thirds of these are reported to and mediated through the Employment Agency. The statistic shows that this subset is biased towards lower skill requirements: In 2018, 40% of non-reported vacancies required a high school diploma or a higher qualification, but only 13% of reported vacancies. 28% of non-reported vacancies were for executives or academics, compared to 10% of the reported vacancies. And while 32% of non-reported job offers paid more than 2.400 Euro per month, just 17% of those reported did so.

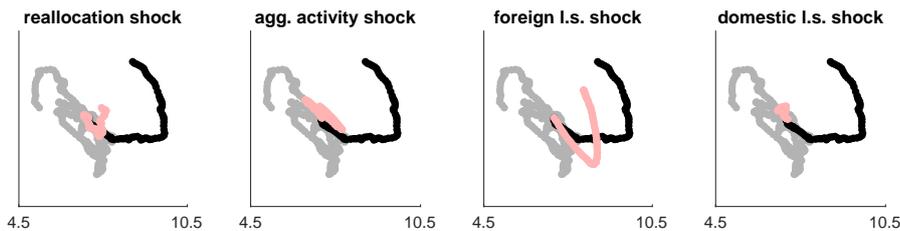


Figure 6: Beveridge Curve counterfactuals, 4-dimensional VAR

Gray dots: realized data up to 2011m4, black dots: realized data as of 2011m5, pink dots: counterfactuals based on the draw close to the point-wise median and with the minimal contribution of deterministic terms to movements in the Beveridge space.

Figure 6 corroborates that the movement in the Beveridge space that was induced by labor supply shocks since mid-2011 was indeed due to supply shocks of foreign workers. Again, the counterfactual exercise is based on the draw with the minimal contribution of deterministic terms that is very close to the point-wise median impulse responses.

Table 3 provides a more detailed overview of the labor force effects of a foreign-worker supply shock. The number of domestic workers, foreign workers and unemployed sum up to the total labor force (apart from rounding errors). On impact, the response of unemployment is very pronounced (50% of the net labor force increase) and it exceeds the negative impact on domestic workers. This means that unemployment among foreign workers rises as well (or that domestic citizens that were out of labor force enter into unemployment in response to immigration, which seems unlikely). After six months the share of foreign employment in the total labor force surplus has significantly increased to the detriment of domestic employment.

	Dom. workers	For. workers	Unemployment	Σ
On impact	-0.1	0.5	0.5	1 (0.2)
After 6 months	-0.5	1.0	0.5	1 (0.6)
After 3 years	-0.2	0.7	0.6	1 (1.1)
After 10 years	0	0.7	0.3	1 (1.0)

Table 3: Composition and size of the labor force surplus induced by foreign labor supply shocks

Not only the composition of the labor force surplus changes. Its total size increases as well within the first six months: from 20% of its long-run median value (i.e. after 10 years) to 60% of it. I assume that the long-run labor force surplus is entirely due

to supply factors, i.e. that induced labor demand effects fade out in the long run. But the relatively small initial size of the surplus (a fifth of its long-run value) points to another feature of labor supply shocks: They are not a short-lived event, like e.g. an unexpected monetary policy decision. Migration takes time and there are network and family effects, so that in the first month only a fifth of the shock materializes. For later periods, though, the number is hard to interpret as labor demand effects kick in. The overlap of demand and supply effects transitorily raises the labor force surplus above its long run value (to 110%). In the long run, the replacement of domestic workers is compensated and heightened unemployment is reduced. Domestic employment is back at its pre-shock level and unemployment remains somewhat above it.

4.3 Regional Beveridge Curves

Given that the labor supply shocks that shifted the Beveridge Curve in recent years emanated from job-related immigration from east neighboring countries, one might expect heterogeneous effects *within* Austria: larger effects in the east and smaller effects in the west. [Schmieder and Weber \(2018\)](#) find that migrant workers from EU-2004 countries “are more likely to work in Vienna or the east of the country than in other parts” (p. 119) and that “the concentration of CESEE-8 immigrants has increased along Austria’s border with CESEE EU Member States. This makes sense given geographic proximity” (ibid.).¹¹ However, they also assess that “with free labor market access, a shift of CESEE-8 workers from east to west occurred” and that “the number of immigrants has increased in the western tourism regions of the country” as well (ibid.).

The availability of monthly data on employment, unemployment and vacancies for Austria’s provinces enables me to conduct a Beveridge Curve analysis on a regional scale. For this purpose, the nine provinces are grouped into three regions (Figure 7). The Eastern region is made up of Vienna, Lower Austria and Burgenland. These provinces constitute an interdependent regional labor market as there is a lot of commuting between them and especially to Vienna, the metropolitan center. Beyond that, these are the provinces that —from a geographical perspective— are most exposed to immigration from Poland, Hungary, Slovakia and the Czech Republic. On the other side of the country, there are three provinces —Vorarlberg, Tirol, and Salzburg— which do not share a border with any of the accession countries. They constitute the Western region and, from a geographical point of view, they are supposed to be least affected by labor

¹¹CESEE-8: 8 Central, Eastern and Southeastern European countries that joined the EU in 2004, i.e. EU-2004 excluding Malta and Cyprus

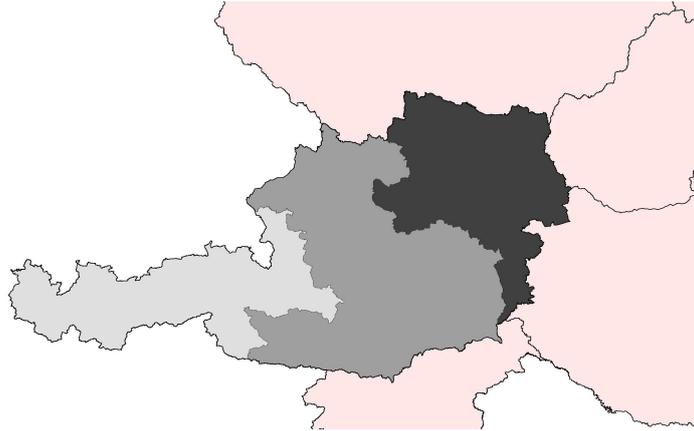


Figure 7: Map of Austria and neighboring/close EU-2004 countries

Pink, clockwise: Czech Republic, Poland, Slovakia, Hungary, Slovenia, black: Eastern region (Vienna, Lower Austria, Burgenland), dark gray: core region (Upper Austria, Styria, Carinthia), light gray: Western region (Salzburg, Tirol, Vorarlberg).

supply shocks. In between the Eastern and the Western region, the three provinces of Upper Austria, Styria, and Carinthia constitute the core. They ought to be less affected by labor supply shocks than the east, and more affected than the west. The data is shown in Figure A5 in the appendix.

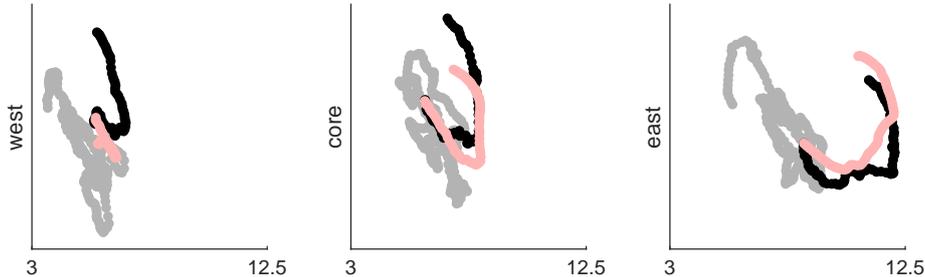


Figure 8: Beveridge Curve counterfactuals, regions

Gray dots: realized data up to 2011m4, black dots: realized data as of 2011m5, pink dots: counterfactuals based on the draw close to the point-wise median and with the minimal contribution of deterministic terms to movements in the Beveridge space.

The empirical results confirm these presumptions. Figure 8 shows the Beveridge Curves for all three regions (gray up to 2011m4, black thereafter) and counterfactuals for labor supply shocks as from 2011m5 (pink). The counterfactuals calculation is based on the baseline specification outlined in Section 3, identified by the draw that exhibits

the minimal contribution of deterministic terms and with impulse responses very close to the point-wise median.

Realized Beveridge Curves already offer some insightful details: The more to the west, the lower the unemployment rate in general and the lower the increase of unemployment since 2011 (scaling of the x-axis is harmonized to establish comparability between the regions). In the east, the marked counterclockwise outward movement of the Beveridge Curve is entirely due to labor supply shocks. In the core, the outward shift of the Beveridge Curve is also almost entirely driven by labor supply shocks, but the shift is less pronounced than in the east. In the west, unemployment increased by even less and, in contrast to the other regions, the Beveridge Curve was hardly affected by labor supply shocks. This is particularly striking for vacancies. In the east and core, the increase of vacancies was largely due to labor supply shocks, but in the west it is identified as a response to a reallocation shock (not shown).

To summarize: Labor supply increased substantially in the east and modestly in the core, raising unemployment correspondingly and, by the ensuing increase of labor demand, also vacancies. The west was not exposed to a labor supply shock, instead a reallocation shock raised labor demand and, hence, vacancies. The simultaneous occurrence of labor supply shocks in the east and reallocation shocks in the west with positive effects on labor demand explain the finding of [Schmieder and Weber \(2018\)](#) that the employment of migrant workers increased in both regions.

Overall, these results suggest that geographical proximity is an important factor of labor supply shocks. This may not come as a surprise, as the Eastern region of Austria is so close to the neighboring countries that migrant workers can commute and, hence, profit from both higher wages in Austria and lower living costs in their home countries. Still, a non-negligible share of migrants are willing to move further away if labor demand rises, as the experience of the Western region demonstrates.

4.4 Further Findings on the Austrian Labor Market

The preceding analysis has demonstrated that a labor supply shock, triggered by foreign workers, moved the Austrian Beveridge Curve substantially. The geographical distribution of the shock and its impact corroborate the presumption that the liberalization of the access to the labor market for Eastern European workers caused this shock. This subsection places the findings on the Beveridge Curve in a broader context of the labor market developments since 2011.

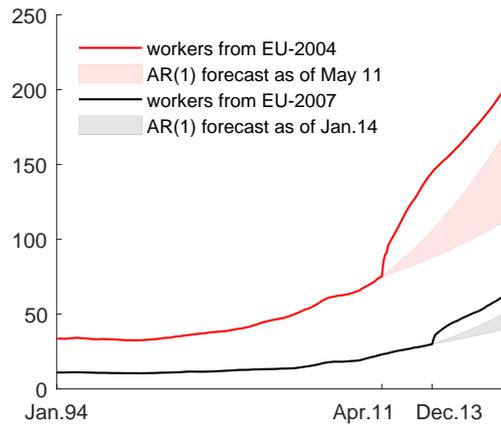


Figure 9: Number of foreign workers, in thousands

Just inspecting the raw data offers some interesting insights. Specifically, the red and black lines in Figure 9 show the time series of the number of workers from EU-2004 and EU-2007 countries. There are obvious jumps in the series in May 2011 and January 2014, i.e. at the dates of labor market liberalization. I perform out-of-sample AR(1) forecasts starting at the corresponding dates; they are represented by the pink and gray areas in the figure (one-standard-error intervals). Given the pronounced jumps in the series at the dates of liberalization, these forecasts can be assumed to be reasonable non-VAR based estimates of a counterfactual without labor market liberalization.

The difference between the realized and the forecast number of workers from both groups is aggregated and plotted as a pink area in Figure 10. The red solid line in this figure shows the increase of foreign workers due to foreign labor supply shocks as identified by the 4-dimensional VAR (i.e. the specification differentiating between foreign and domestic workers). This VAR-based estimate of labor supply shocks is largely within the AR-based forecast interval (the pink area), in particular at later horizons. In the early stages of liberalization, the pink area lies above the red solid line, i.e. the actual increase of workers from EU-2004 and EU-2007 countries appears to have been stronger than the overall shock to foreign workers. This suggests that newly arriving workers displaced existing ones to a certain extent.

Figure 10 also shows the estimated responses of the other variables of the VAR model. The rise in unemployment (black dot-dashed line) and the lagging increase in total employment (red dot-dashed line) relative to the extra amount of foreign workers also

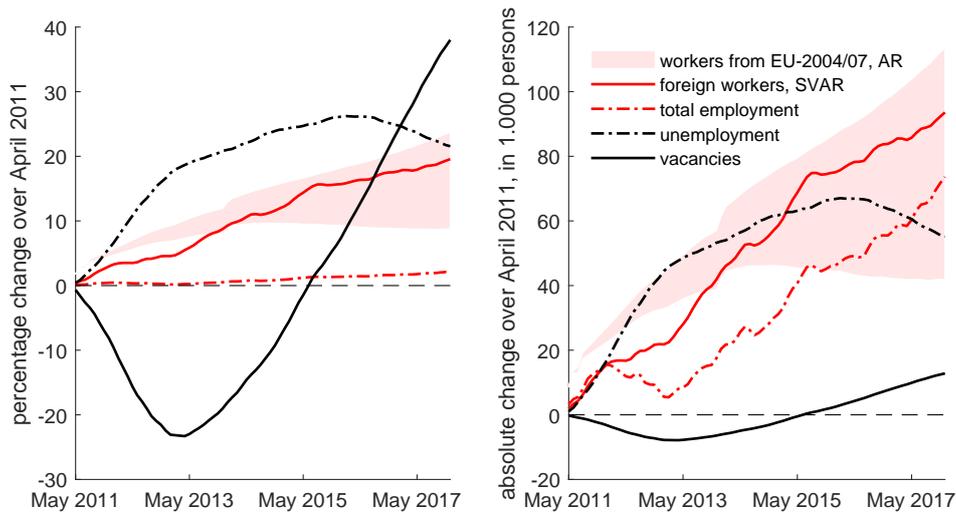


Figure 10: Effects of foreign labor supply shock

Lines: effects of foreign labor supply shocks based on the VAR draw close to the point-wise median and with the minimal contribution of deterministic terms to movements in the Beveridge space, pink areas: difference between realized number of workers from EU-2004 and EU-2007 countries and AR(1) forecasts as of May 2011 and January 2014, respectively (see Figure 9).

point to displacement effects. While the absolute numbers of extra foreign workers, total employment and unemployment are of comparable magnitude (right panel of the figure), the percentage changes (left panel) differ substantially. This observation also applies to the number of vacancies, which responds heavily on a relative scale, but less than the other variables when measured in absolute terms.

Specifically, the change of vacancies induced by the labor supply shock reaches a trough of minus a quarter after two years. In absolute terms, the decline over this horizon is roughly equivalent to the amount of additional total employment. The increase in unemployment peaks after five years (plus 25%). Until then, it exceeds the number of additional jobs (total employment) that has been created in the wake of the labor supply shock. At the end of the sample period (end of 2017), vacancies are up by almost 40%, the number of foreign workers and unemployment by 20% and the number of total workers by 2.2% compared with the counterfactual of no foreign labor supply shocks. This suggests that these shocks had a strong impact not only on the Beveridge Curve but also on other parts of the labor market — and the economy as a whole, as the following section demonstrates.

5 Extensions

The 3-dimensional baseline model has several benefits. It is parsimonious and it allows for the identification of labor supply shocks with minimal assumptions, while remaining universal with respect to other shocks. The inclusion of employment allows to disentangle domestic and foreign worker shocks. Availability of the three variables on a subnational level provides regional estimates and, hence, further insights.

But these benefits could come with potential deficiencies: Parsimoniousness could lead to mis-specification if the model lacks important variables, like e.g. wages. The use of few assumptions could weaken the identification of labor supply shocks; [Canova and Paustian \(2011\)](#) find that it's easier to recognize the data generating process when more variables are restricted for a given number of shocks, or if more shocks are identified. To address these concerns, I apply a very recent framework developed by [Faroni et al. \(2018\)](#), who derive robust sign restrictions from a New Keynesian model with endogenous labor supply.

	real output	inflation	real wages	unemployment rate	vacancies
demand shock	+	+		–	
technology shock	+	–	+		
labor supply shock	+	(–)	–	+	
wage bargaining shock	+	–	–	–	+
matching efficiency shock	+	–	–	–	–

Table 4: Impact sign restrictions, [Faroni et al. \(2018\)](#)

Compared to the baseline specification, it amounts to dropping employment and adding real output (GDP), inflation and real wages. Data frequency is quarterly, the sample period hence 1988q1 – 2017q4. All variables with the exception of the unemployment rate are expressed in terms of natural logarithms. Inflation is measured as first difference of the GDP deflator (results are robust to using the consumer price index).¹² Real wages are measured in per capita terms (results are robust to using real wages per hours worked). In contrast to the baseline model, the unemployment rate enters directly instead of being calculated ex post. Apart from labor supply shocks, four other macroeconomic shocks are identified: demand shocks, technology shocks, wage bargain-

¹²I use inflation instead of prices for stationarity reasons. Results are robust to estimating the model with prices, but confidence bands get larger.

ing shocks and matching efficiency shocks. The respective sign restrictions are given in Table 4, which corresponds to Table 3 in [Forni et al. \(2018\)](#).

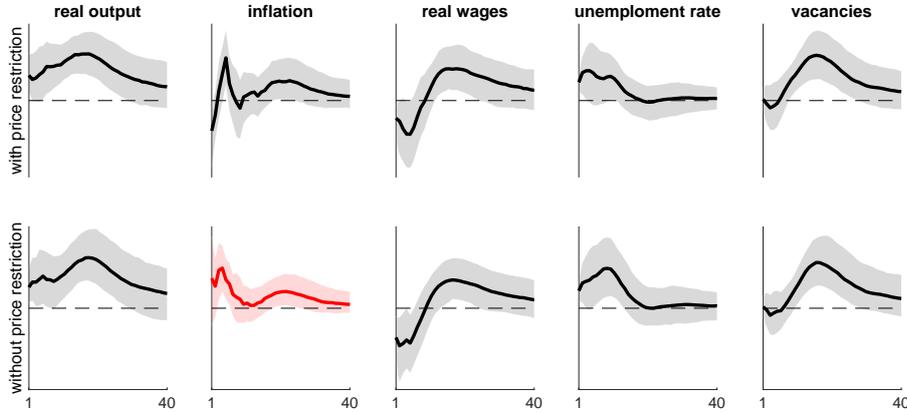


Figure 11: Impulse responses to labor supply shocks, 5-dimensional VAR. Point-wise medians and 68% credible sets, horizon: 10 years (40 quarters).

In the 3-dimensional baseline model, labor supply shocks are identified on the assumption of a positive conditional covariance of employment and unemployment on impact. In the 5-dimensional framework a positive conditional impact covariance of real GDP and the unemployment rate is imposed instead. Furthermore, a negative impact response of wages is set to separate labor supply shocks from technology shocks. On top of that, a negative impact response of prices is set. This restriction, however, is not *necessary* for identification, it might merely serve as an *improvement* of identification in the sense of [Canova and Paustian \(2011\)](#).

But this is questionable given the pattern of impulse responses: According to [Figure 11](#), upper row, inflation exhibits an immediate sign reversal in response to labor supply shocks.¹³ More importantly, this is not an anomaly in Austrian data, but it has been observed in previous empirical work as well: For the US, [Forni et al. \(2018, Figure 1\)](#) show that the response of prices to a labor supply shock reverses quickly after its negative impact response to which it is restricted. The sign reversal applies to the entire credible set, not only to some draws. [Furlanetto and Robstad \(2019, Figure 11\)](#) find a similar pattern in Norwegian data (see also Figures 11 and 12 in the online appendix to their paper), and [Smith and Thoenissen \(2019\)](#) for house prices in New Zealand.

¹³The response of prices equals the accumulated response of inflation; it stays strictly positive after the quick sign reversal.

As the price restriction is not necessary for the identification of the labor supply shock another estimation is performed without it. The respective impulse responses are presented in the lower row of Figure 11. It turns out that in the majority of draws the price response to labor supply shocks is *positive*; only a minority of draws displays negative effects. The other impulse responses remain unaltered, those to labor supply shocks as well as to the other identified structural shocks (cf. Figures A7 and A8 in the appendix). From this observation it follows that the negative impact restriction of prices in response to labor supply shocks represents only the tail of the distribution. Labor supply shocks seem to be predominantly inflationary, which might hold not only for Austrian data, but also for Norwegian and US data, as discussed above.

Another ubiquitous empirical finding is the medium-run reversal of the response of wages. It also points to substantial labor demand effects. Labor demand is fostered because wages are dampened in response to labor supply shocks, which is also reflected in the response of the other variables: the increase of vacancy postings, the acceleration of GDP growth and the reduction of unemployment, all taking place in the medium run. The behavior of prices and wages suggests that this demand effect is stronger than predicted by theoretical models.

Apart from the general relevance of these results, the price effect in particular has further implications for the identification of labor supply shocks. Forni et al. (2018) have demonstrated that the identification of labor supply shocks can be improved by including the participation rate as a further endogenous variable next to the unemployment rate. The inclusion and proper restriction of the participation rate seems to make the restrictions on the response of the unemployment rate redundant (Furlanetto and Robstad, 2019).

The inflationary effect of labor supply shocks calls for caution in this regard. It implies that labor supply shocks and aggregate demand shocks might not be identified properly in the absence of a restriction of unemployment even if the participation rate is included. To see why this is the case, note that the response of the participation rate to aggregate demand shocks is not restricted, i.e. participation may either increase or decrease on impact. The inclusion of the participation rate improves the identification of other shocks, but not of demand shocks. This leaves two options to disentangle labor supply shocks from aggregate demand shocks (like in the baseline specification without participation): either by a pairwise restriction of GDP and prices or by a pairwise restriction of GDP and unemployment. The inflationary effect suggests that labor supply shocks can have the same positive conditional correlation of GDP and prices as demand

shocks. Hence, a pairwise restriction of GDP and prices is in fact not viable and one has to resort to the pairwise restriction of GDP and the unemployment rate. From this it follows that labor supply shocks might not be properly identified without imposing a restriction on the unemployment rate, which entered New-Keynesian models precisely for that purpose (Galí et al., 2011).¹⁴

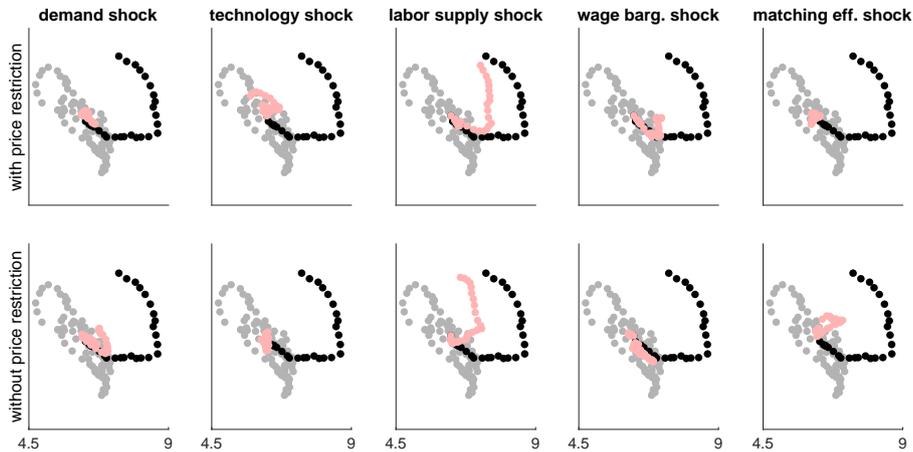


Figure 12: Beveridge Curve counterfactuals, 5-dimensional VAR, with and without sign restriction on prices in response to labor supply shocks

Gray dots: realized data up to 2011q1, black dots: realized data as of 2011q2, pink dots: counterfactuals as of 2011q2 if only the shock mentioned in the title had prevailed, based on the draw close to the point-wise median and with the minimal contribution of deterministic terms to movements in the Beveridge space.

Apart from the anomalies presumably related to strong demand repercussions, the remaining results of this estimation exercise are fairly innocuous. The positive response of production (GDP) is sluggish. It takes some quarters for the growth enhancing effect of labor supply shocks to unfold, which peaks at around 4–5 years after the initial impulse. The imposed negative effect on wages is transitory and reversed in the medium run; a result that is also in line with the work on the US and Norway cited above. Similarly to the results from the 3-dimensional baseline specification, the rise of unemployment is transitory and reversed in the medium run. Also consistent with the previous result is the weak initial response of vacancies. The medium run increase of vacancies is more pronounced than in the baseline model. The counterfactual analysis confirms that the

¹⁴Evidence against an increase of unemployment in response to an immigration shock as a specific form of labor supply shocks is provided by Peri (2012), d’Albis et al. (2019) and Furlanetto and Robstad (2019).

counterclockwise outward movement of the Beveridge Curve since 2011 was mainly due to labor supply shocks (Figure 12). Other structural shocks originating from the labor market, i.e. wage bargaining shocks or exogenous changes of matching efficiency, did not move the Beveridge Curve in recent years.

6 Conclusion

In this article I study the effects of labor supply shocks on Beveridge Curve dynamics with a focus on shocks exerted by foreign workers which emanate from job-related immigration. European integration has fostered labor migration, since the free movement of labor is one of the core principles of the EU treaty. Labor market integration gained momentum in mid-2011, when Germany and Austria granted this principle to the Central and Eastern European countries that joined the European Union in 2004. I study the effects on the Austrian labor market, which was particularly affected due to its geographical exposure and high income gap to these countries.

It turns out that the counterclockwise outward shift of the Beveridge Curve is to a large extent related to labor supply shocks caused by job-related immigration. In the short run these shocks churn the labor market and the employment of domestic workers transitorily declines. Furthermore, the burden of adjustment is spread unevenly across regions. Regions close to the Eastern border suffer most from an increase of unemployment, the further to the west the smaller the effect. I also confirm results for the US and for Norway that labor supply shocks are most likely inflationary, in contrast to standard theory. From this it follows that labor supply shocks might not be properly identified without resorting to some restriction of the unemployment rate.

A promising path for future research would be to examine the impact of labor supply shocks on prices in more detail and, if necessary, amend theoretical models accordingly. In addition, further empirical evidence on labor supply shocks in other countries is needed as migration remains a key issue for both economists and humanity as a whole.

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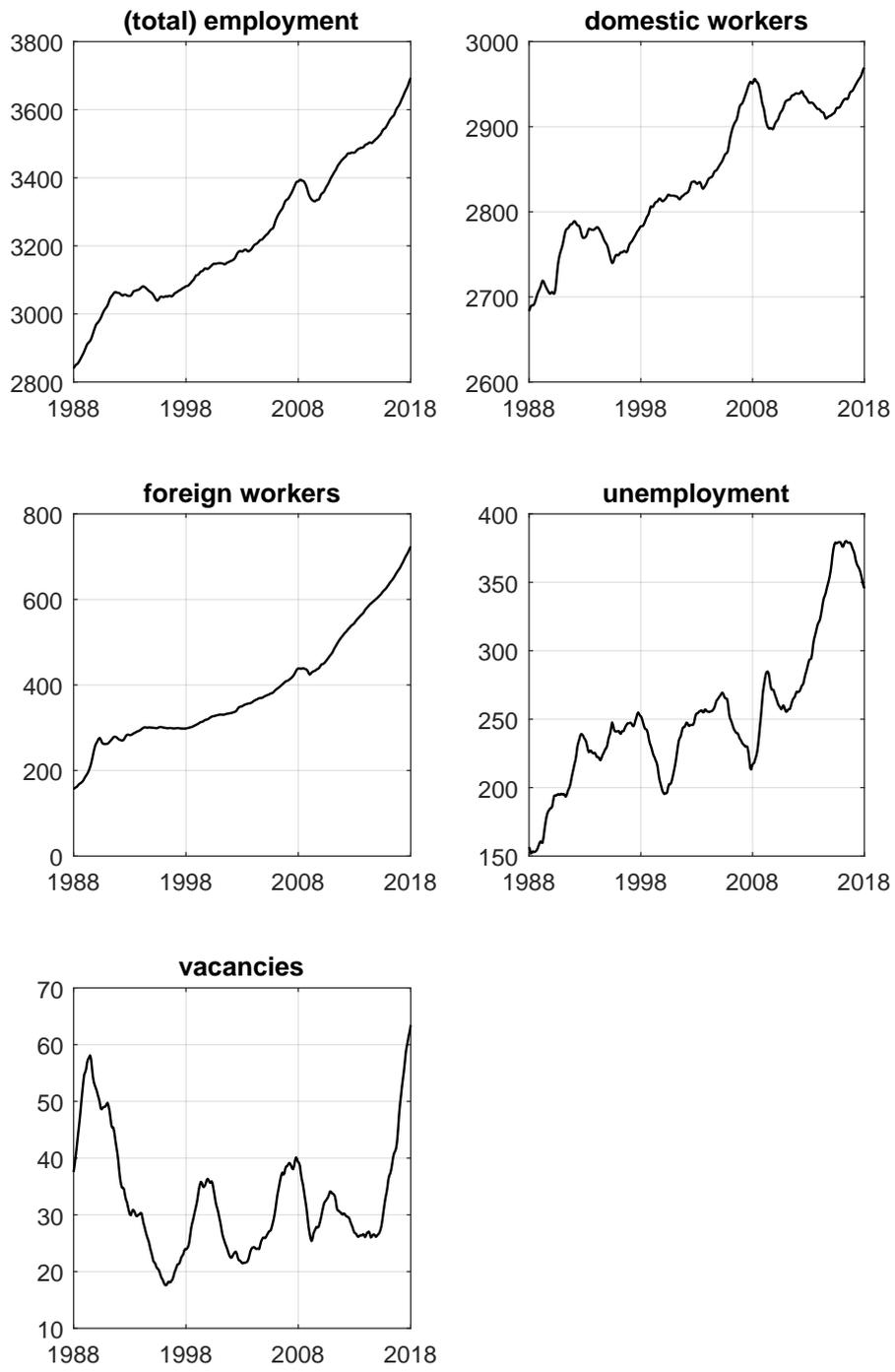


Figure A1: Data, baseline model (thousands of persons)

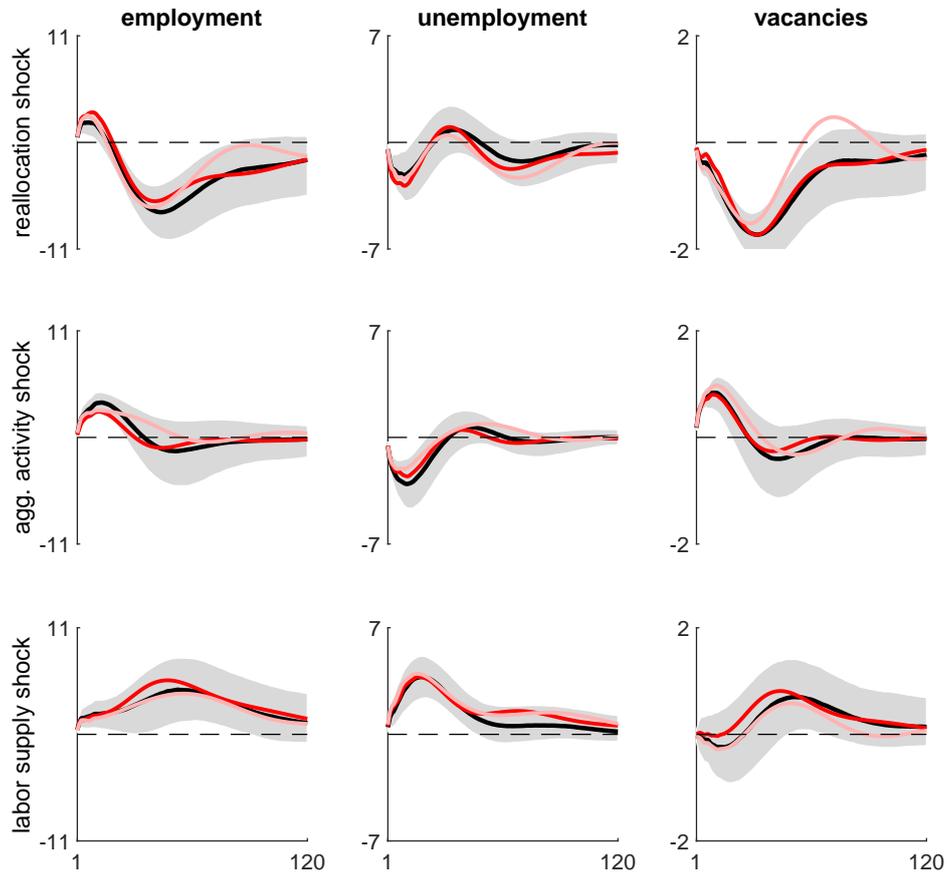


Figure A2: Impulse responses, baseline model

Point-wise medians (black), median target draw (red), draw close to the point-wise median and with the minimal contribution of deterministic terms to movements in the Beveridge space (pink, cf. Section 4.1) and 68% credible sets (gray areas), horizon: 10 years (120 months), unit: in thousands.

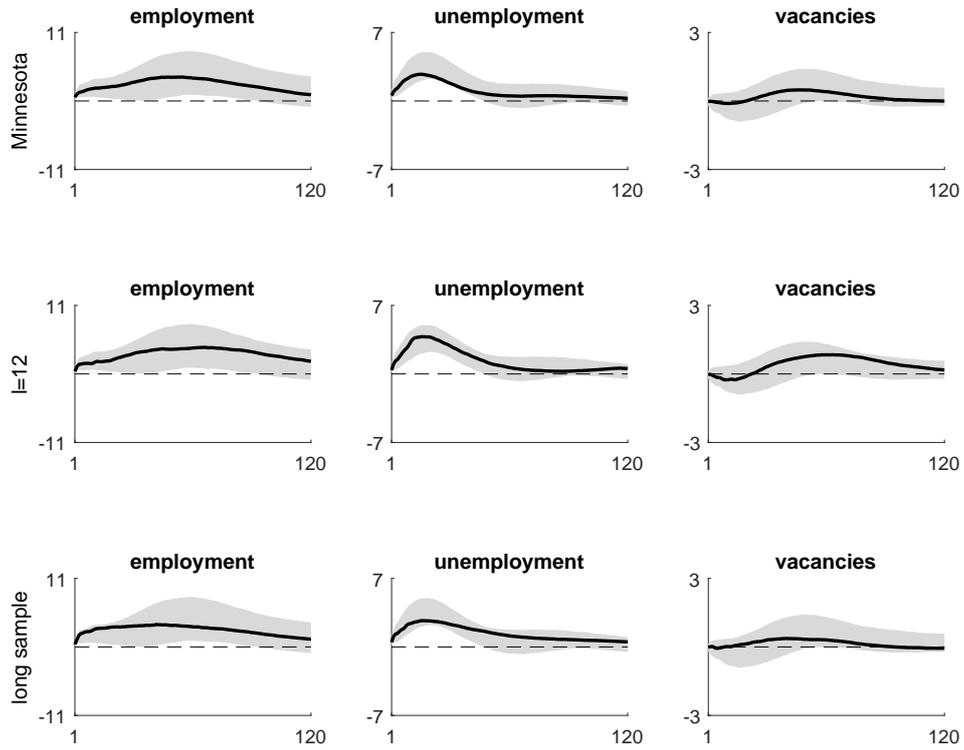


Figure A3: Impulse responses to labor supply shocks, various specifications
 Minnesota prior, lag length $l = 12$ and long sample starting at 1960m1.

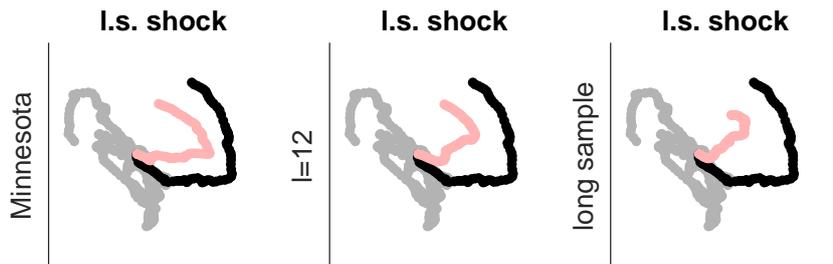


Figure A4: Labor supply shock Beveridge Curve counterfactuals, various specifications

Minnesota prior, lag length $l = 12$ and long sample starting at 1960m1.

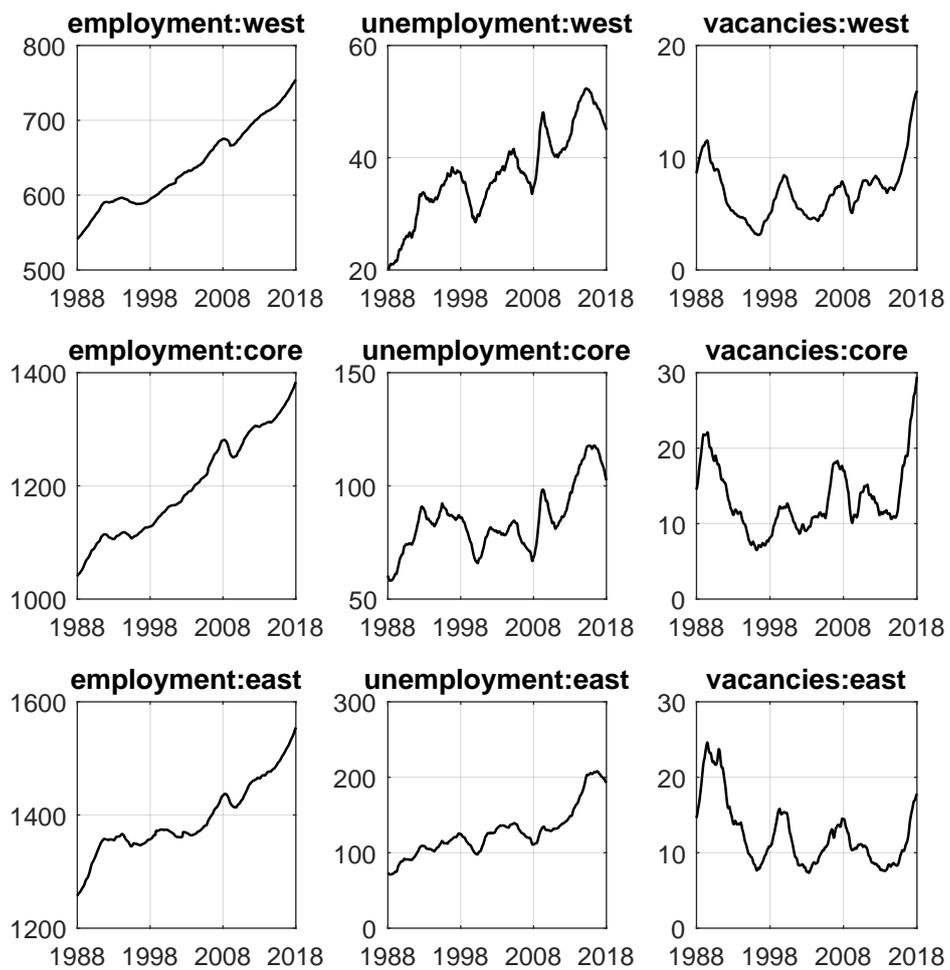


Figure A5: Data, regional models (thousands of persons)

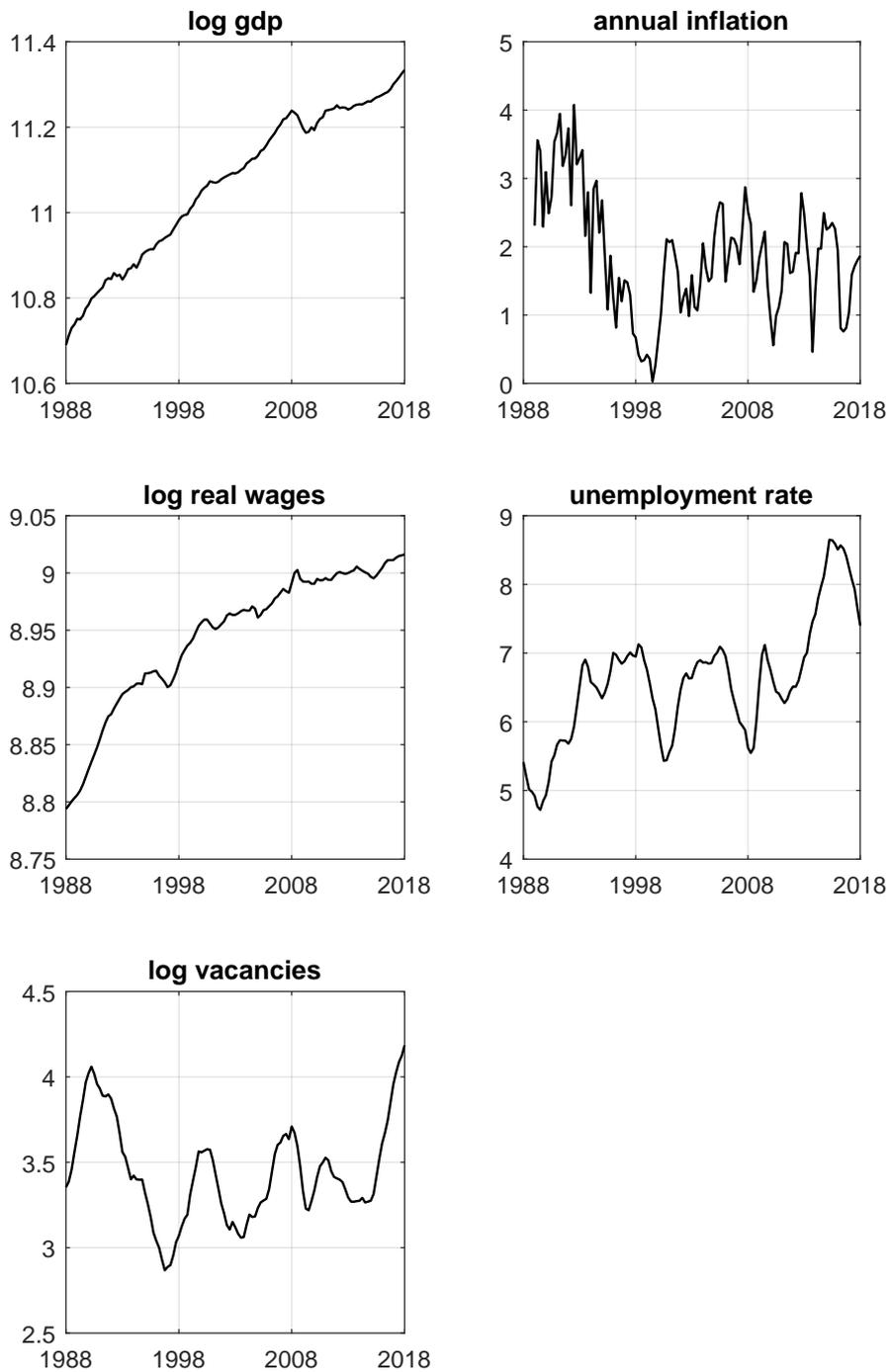


Figure A6: Data, extended model

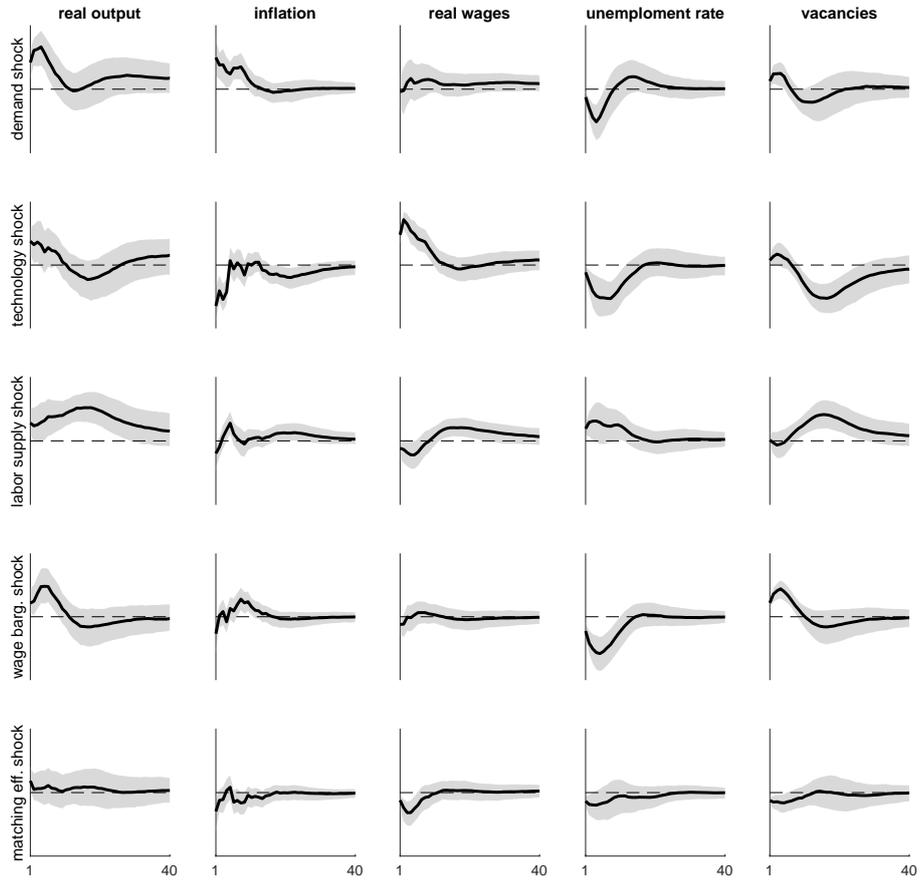


Figure A7: Impulse responses, 5-dimensional VAR, identification as in [Foroni et al. \(2018, Table 3\)](#)

Point-wise medians and 68% credible sets, horizon: 10 years (40 quarters).

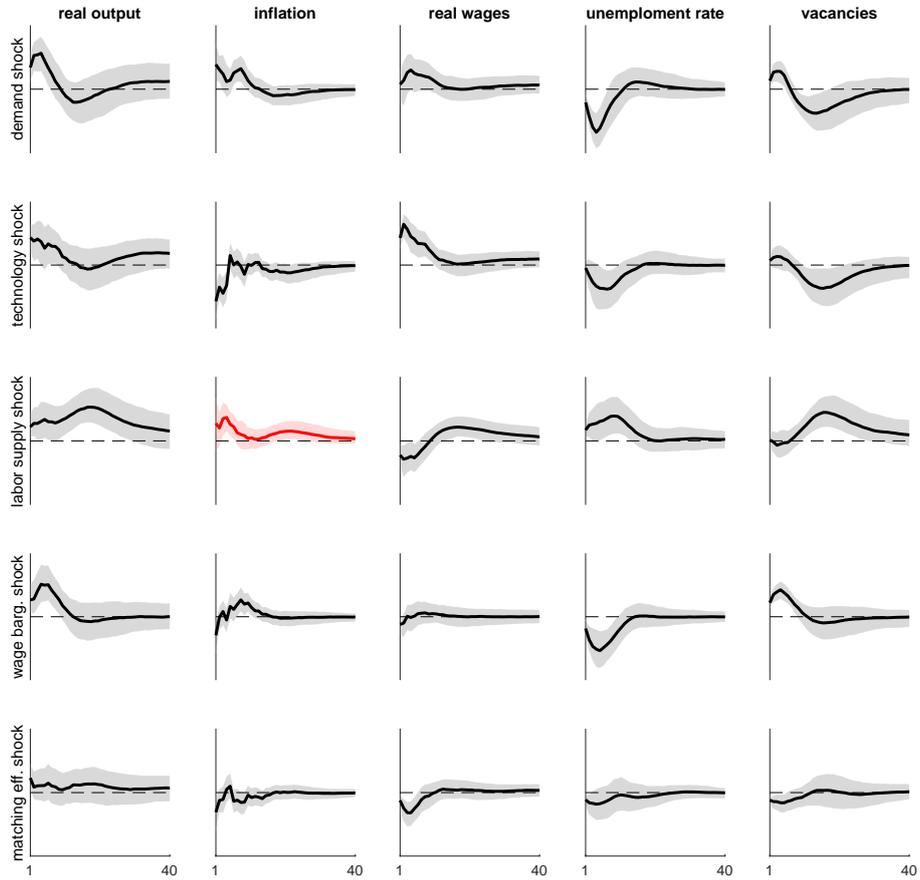


Figure A8: Impulse responses, 5-dimensional VAR, without price restriction on labor supply shock

Point-wise medians and 68% credible sets, horizon: 10 years (40 quarters).