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Empirical Evidence from Austria

Stefan Schiman

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Working Paper

Labor Supply Shocks and the Beveridge Curve: Empirical Evidence from Austria

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Austria's Beveridge Curve has shifted markedly outwards since labor market access for Eastern European neighbors was liberalized in 2011. I quantify the effects of labor supply shocks by means of a structural VAR with sign restrictions, distinguish domestic-worker from foreign-worker shocks and find that the latter contributed considerably to the counterclockwise outward movement. On impact, the arrival of additional job seekers facilitates matching but it lowers the chance for existing job seekers to be matched, raising employment and unemployment simultaneously. In the medium run vacancies increase, the employment surge accelerates and unemployment declines. Labor supply shocks caused by foreigners have an unambiguous and positive effect on domestic employment in the long run, indicating complementarity between foreign and domestic labor. On a regional level Vienna, the capital in the east of the country, was most heavily exposed to the recent labor immigration boom.

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

JEL classification: C32, F66, J21, J63

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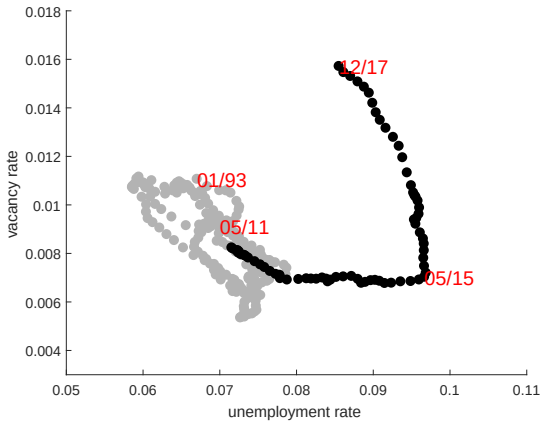

Figure 1: Beveridge Curve, 1993 – 2017

1 Introduction

The negative relationship between the unemployment rate and the job vacancy rate, named after the British economist William Beveridge, has caught attention over decades [Rodenburg, 2011]: to determine the stance of the business cycle [Dow and Dicks-Mireaux, 1958], to distinguish structural from cyclical unemployment [Jackman et al., 1990] and, eventually, as 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, as the Great Recession left its marks in the Beveridge Space of the US [Furlanetto and Groshenny, 2016, Daly et al., 2012], and of other developed countries [Hobijn and Şahin, 2013]. This was not the case, though, for Austria: The labor market was robust to international turmoil and the Beveridge Curve remained on a long-term locus during and after the economic crisis. It took until 2011, when things started to normalize in other countries, that Austria's Beveridge Curve embarked on a marked outward shift (figure 1). Not only the size of the shift is remarkable but also the trajectory: a stark horizontal rightward shift was followed by a steep upward movement. This raises doubt whether factors that are usually invoked as Beveridge Curve shifters, such as reallocation shocks or matching efficiency shocks, can explain this shift entirely, as they would suggest a somewhat *simultaneous* rise of unemployment and vacancies.

In this article, I argue that a substantial part of this shift is not related to the woes of the Great Recession and its aftermath, but to a deliberate policy decision in conjunction with European integration: the liberalization of labor market access for several Central and Eastern European countries in May 2011, which induced a significant labor supply shock. The benefiting countries were Poland, Hungary, the Czech Republic, Slovakia, Slovenia, Esto-

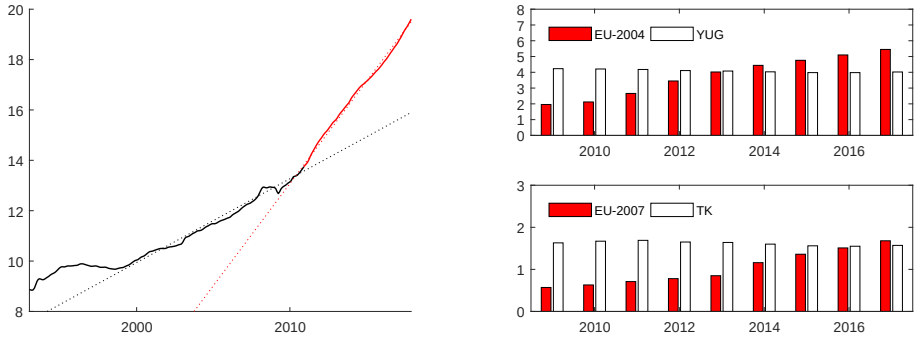

Figure 2: Share of foreign workers in total employment (in %)

nia, Latvia and Lithuania, four of which share a common border with Austria. Germany and Austria granted the principle of free movement to this group of countries at the latest acceptable date. All other EU member states granted access to their labor markets earlier, some of them right away with the accession of the new member states in 2004. Apart from geographical proximity, Austria was particularly affected by the opening of its labor market, because the income gap towards these countries is large raising the incentive for labor migration. Prior to 2011, labor market access was rather restrictive. Work permits had to be requested for each individual applicant, they were granted maximally up to one year and only if there was no suitable candidate on the domestic job market.

The increase of the share of foreign workers accelerated substantially in 2011. This is stressed by the trend lines in the graph on the left-hand side of figure 2 and emphasized by different coloring of the line before and since 2011. The graph on the right-hand side shows that the rise of the share of foreign workers accelerated on account of workers who benefited from the liberalization of labor market access[1]. As the number of job seekers increased on the domestic labor market, competition for vacancies intensified which made it more difficult for existing job seekers (unemployed) to be matched to a vacancy, bolstering the stock of unemployment. The slack in the labor market made recruitment less costly incentivizing firms to post more vacancies, which bolstered employment and dampened the heightened level of unemployment. Altogether, it resulted in a counterclockwise movement in the Beveridge Space, similar to what can be observed in the data.

[1] In January 2014 restrictions on labor market access were abolished for countries that joined the European Union in 2007 (Romania, Bulgaria). The development of these groups of workers is compared to the share of workers from former Yugoslavia and Turkey, who constituted the largest non-German speaking groups prior to liberalization. Labor immigration from there started as early as in the 1960s with "guestworker" recruitment.

I estimate the effects of labor supply shocks on the Beveridge Curve by means of vector auto-regressive models. The baseline specification contains employment, unemployment and vacancies as endogenous variables, in the vein of Blanchard and Diamond [1989]. Apart from a proper identification of labor supply shocks, this variable choice enables me to carry out estimation in levels and construct counterfactual unemployment and vacancy *rates* ex-post. To identify labor supply shocks and distinguish them from other shifters of the Beveridge Curve and from shocks along the Beveridge Curve I employ sign restrictions. The theoretical labor market model requires another restriction on the elements of the impact multiplier matrix, which shrinks the set of admissible models substantially and in an economically reasonable way. I am not the first to use additional information along with sign restrictions: Kilian and Murphy [2012] have done so for oil shocks, but their restriction is based on empirical grounds. I proceed with extending the baseline VAR by foreign employment and distinguish labor supply shocks caused by domestic workers from labor supply shocks caused by foreign workers with identification assumptions similar to Furlanetto and Robstad [2016]. Regional estimates add further nuances to the analysis, as they show that the east of the country was more affected by the recent boom of labor immigration and that especially Vienna as a metropolitan region was most heavily exposed to it.

The analysis proceeds as follows: Section 2 reviews a descriptive model of employment, unemployment and vacancies that is considered the benchmark to analyze Beveridge Curve dynamics. Section 3 introduces the VAR and the identification assumptions. A discussion of impulse responses, forecast error variance contributions and estimated elasticities in section 4 will convince the reader that the chosen approach is capable of identifying labor supply shocks properly. Section 5 presents counterfactual Beveridge Curves. In section 6 domestic-worker and foreign-worker shocks are disentangled, and section 7 examines regional aspects. Robustness checks in section 8 corroborate the findings and section 9 concludes.

2 Theoretical framework

The following descriptive model of employment, unemployment and vacancies is meant to summarize important mechanisms in the Beveridge Space. It represents a slight adaptation of the benchmark model presented by Elsby et al. [2015b] to incorporate exogenous labor

supply shifts in the vein of Blanchard and Diamond [1989].

$$\dot{\mathbf{E}} = \mathbf{H}(e, U + f, V) - \mathbf{C}(d, r) \tag{1}$$

$$\dot{\mathbf{V}} = \mathbf{F}\left(r, p, c\left(fr(V/U)^{-1}\right)^{-1}\right) - \mathbf{H}(e, U + f, V) \tag{2}$$

$$\dot{\mathbf{L}} = \theta\dot{\mathbf{E}} + f \tag{3}$$

and from $L = E + U$ it follows that

$$\dot{\mathbf{U}} = (\theta - 1)\dot{\mathbf{E}} + f \tag{4}$$

E is employment, V are vacancies, L is the labor force, U is unemployment. Dots denote time derivatives, plain capital letters denote stock variables, bold capital letters denote flows and small letters capture various parameters. All functions are increasing in their arguments. Inflow to employment and the filling of vacancies are both driven by new hires $\mathbf{H}$, which are governed by a matching function. Hence, they are positively related to the number of job seekers (unemployed plus new members of the labor force f) and to the number of vacancies, as either facilitates matching. Total matching efficiency e is determined by workers' skills, by geographical dispersion of job seekers and job offers, etc. A deterioration of matching efficiency shifts the Beveridge Curve outwards as hiring declines and unemployment and vacancies increase (the former due to a decline of employment). A link between the outflow from employment $\mathbf{C}$ (into unemployment or out of labor force) and the flow of new vacancies $\mathbf{F}$ is established via r, the intensity of sectoral reallocation in the economy. Intensification of structural change means more job closures in declining sectors and more job openings in rising sectors; another reason for lateral Beveridge Curve shifts. Unemployment and vacancies would also rise simultaneously if the quit rate (i.e. the propensity of employees to leave a job voluntarily) increases and if a new vacancy is posted for each quit. Furthermore, jobs are closed by the employer, i.e. without new vacancies being posted, at a job destruction rate d. Vacancy creation is fostered by higher worker productivity p, which can be regarded as a counterpart to job destruction: While d denotes the rate at which productive tasks become unproductive (and therefore unprofitable), p can be regarded as the rate at which unproductive tasks become productive. In that sense r is a composite factor of d and p. Beyond that, vacancies are subject to recruitment costs c for the period they remain unfilled with the filling rate fr increasing in labor market tightness V/U. The less tight the labor market (the higher unemployment), the easier vacancies are filled, the lower the overall recruitment cost and the higher the incentive for firms to create new vacancies. This positive relationship between unemployment and vacancies is sometimes referred to as the Job Creation Curve as opposed to the negatively sloped Beveridge Curve. To summarize, it is possible to differentiate between two categories of shocks that influence the position in the Beveridge Space:

- shocks that induce a shift of the Beveridge Curve (shocks to matching efficiency, shock to the intensity of reallocation),

- shocks that induce a movement along the Beveridge Curve (shocks to worker productivity, shocks to the jobs destruction rate).

While the latter are often associated with shocks that govern the business cycle, the former are rather classified as structural changes. The dynamics discussed so far are based on the implicit assumption that unemployment reacts negatively to changes of employment, i.e. $\theta < 1$. This is not only a reasonable assumption, but it is also crucial to distinguish labor supply shocks f from the other shocks in the system. A positive labor supply shock is defined as positive net inflow of job seekers from out of labor force into the labor force. More job seekers facilitate the matching of vacancies, reducing the search time for the firm and recruitment costs and bolstering the stock of employment. On the other hand, more job seekers make it more difficult for existing unemployed to be matched to a vacancy, increasing their search time and, bolstering the stock of unemployment. Thus, a positive labor supply shock raises employment *and* unemployment on impact. For vacancies, on the one hand, there is an immediate dampening effect due to increased hiring by firms. On the other hand, as recruitment costs decline, firms have an incentive to post more vacancies. If the latter effect kicks in fast enough, the *observable* impact effect (i.e. the effect in the first month after the shock) might be indeterminate. As the positive impact comovement of employment and unemployment is sufficient to distinguish labor supply shocks from the other shocks in the system, I will leave the response of vacancies unrestricted and let the data speak on that.

3 Empirical model

Let

$$\mathbf{y_t} = \mathbf{C} + \sum_{i=1}^{l} \mathbf{A_i} \mathbf{y_{t-i}} + \mathbf{u_t} \tag{5}$$

be the reduced-form model, where $\mathbf{y_t}$ is a vector of endogenous variables, $\mathbf{C}$ is a matrix of constants and time trends, $\mathbf{A_i}$ are reduced-form coefficient matrices and $\mathbf{u_t} \sim \mathcal{N}(\mathbf{0}, \mathbf{\Sigma_u})$ is a vector of reduced-form residuals. Data are in monthly frequency, seasonally adjusted and range from 1960m1 to 2017m12 (696 observations)[2].

[2]The 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: LMUNRLTTATM647N (FRED), LMUNRLTT (OECD); unemployment rate: LMUNRRTTATM156N (FRED), LMUNRRTT

The model is estimated with Bayesian techniques, employing a Normal-Wishart prior on $\mathbf{a} = vec([\mathbf{A_1}, ..., \mathbf{A_l}])$ and $\mathbf{\Sigma_u}$:

$$\mathbf{a} \sim \mathcal{N}(\mathbf{a}^*, \mathbf{V_a}) \tag{6}$$

$$\mathbf{\Sigma_u} \sim \mathcal{IW}(dof, scl) \tag{7}$$

The reduced-form coefficients follow a Normal distribution with prior mean $\mathbf{a}^* = \mathbf{0}$ and prior variance $\mathbf{V_a} \to \infty \cdot \mathbf{I}$ as the prior precision $\mathbf{V_a^{-1}}$ is set to zero. The reduced-form residuals follow an Inverse Wishart distribution with prior parameters $dof = scl = 0$. The drawback of the conjugate form of this prior is that $\mathbf{V_a} = \mathbf{V} \otimes \mathbf{\Sigma_u}$, i.e. $\mathbf{a}$ and $\mathbf{\Sigma_u}$ are not independent. As this condition is rather restrictive, a Gibbs sampler is used instead of the conjugate form [Kilian and Lütkepohl, 2017]. I only consider stationary draws, i.e. draws with absolute eigenvalues of the companion matrix of posterior reduced-form coefficients smaller than one. The lag order l is set to 6 (months).

The Bayesian approach facilitates structural identification via sign restrictions in an efficient way that has become standard in the literature [Rubio-Ramírez et al., 2010]. To obtain orthogonal residuals $\mathbf{w_t} = \mathbf{B u_t}$, $\mathbf{B}$ is chosen such that $\mathbf{\Sigma_w}$ is diagonal. Scaling the variance of each orthogonal innovation to unity gives $\mathbf{\Sigma_w} = \mathbf{I}$, such that $\mathbf{\Sigma_u} = \mathbf{B^{-1}B^{-1'}}$ and where $\mathbf{B^{-1}}$ is the impact multiplier matrix containing the impact responses of the variables to the orthogonal residuals (structural shocks). In a first step, $\mathbf{B^{-1}}$ is chosen according to a Cholesky decomposition of $\mathbf{\Sigma_u}$. Since this procedure leaves some $b_{ij} \in \mathbf{B^{-1'}}$ restricted to zero, the Cholesky factors are extended by the product of an orthogonal matrix (the so-called rotation matrix) and its transpose, which gives $\mathbf{\Sigma_u} = \mathbf{PP'} = \mathbf{PQQ'P'}$, where $\mathbf{P} = chol(\mathbf{\Sigma_u})$. The orthogonal rotation matrix $\mathbf{Q}$ is obtained via a QR decomposition of a matrix $\mathbf{Z}$ that is sampled from a standard Normal distribution, and it is selected such that the sign restrictions on $\mathbf{B^{-1}} = \mathbf{PQ}$ are satisfied[3].

$b_{ij} \in \mathbf{B^{-1'}}$	*une*	*emp*	*vac*
labor supply shock, f	+	+	
shocks of the Beveridge Curve, s	+	−	+
shocks along the Beveridge Curve, c	+	−	−

Table 1: Impact sign restrictions

The researcher has to take a stance on whether to model "positive" or "negative" shocks, which comes without loss of generality as they are equivalent in a linear model (i.e. the size

(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.

[3]Authors that have used the sign restriction approach to identify labor market shocks include Foroni et al. [2018], Hairault and Zhutova [2018] and Fujita [2011], among others.

of the effects is independent of the sign of the shock). I choose all shocks to have a positive impact effect on unemployment, which amounts to a *downward* movement along the Beveridge Curve, an *outward* shift of the Beveridge Curve and an exogenous *increase* of labor supply, respectively (table 1). In addition to these sign restrictions the theoretical framework outlined above provides another restriction, as the parameter of endogenous labor supply elasticity θ appears twice in $\mathbf{B^{-1}}$. To recognize this and another useful elasticity, it is convenient to rewrite $\mathbf{u_t} = \mathbf{B^{-1}w_t}$ in full detail:

$$u_{une,t} = b_{11}w_{f,t} + b_{21}w_{s,t} + b_{31}w_{c,t} \tag{8}$$

$$u_{emp,t} = b_{12}w_{f,t} + b_{22}w_{s,t} + b_{32}w_{c,t} \tag{9}$$

$$u_{vac,t} = b_{13}w_{f,t} + b_{23}w_{s,t} + b_{33}w_{c,t} \tag{10}$$

The labor force varies endogenously by a factor θ in response to employment *independent* of the nature of the shock that moves employment. Since in the parsimonious specification that is used here, these shocks are grouped into two categories, θ appears as $\frac{b_{21}+b_{22}}{b_{22}}$ and $\frac{b_{31}+b_{32}}{b_{32}}$. The restriction also holds in a richer macroeconomic framework like the New Keynesian DSGE model with endogenous labor force participation proposed by Christiano et al. [2015]. In very recent work this model has been applied by Foroni et al. [2018] to study labor market dynamics. In their notation (cf. the online supplement of their paper), the size of the labor force in period t is given by

$$L_t = \omega(L_{t-1} - N_t + \rho N_{t-1}) + (1-\rho)N_{t-1} + \tau_t \tag{11}$$

where N is employment, ρ is an exogenous job destruction rate, τ_t is a labor force shock and ω is an *exogenous* "staying rate" and, as such, corresponds to the labor supply elasticity θ. Therefore $\frac{b_{21}}{b_{22}} \approx \frac{b_{31}}{b_{32}}$ is imposed as a further identifying restriction apart from the sign restrictions given in table 1. Beyond that, the above system of equations reveals another interesting elasticity $\lambda = \frac{b_{12}}{b_{11}+b_{12}}$, which is the employment elasticity of a labor supply shock. Since by construction $0 < \lambda < 1$, $\lambda < 0.5$ means that a labor supply shock raises unemployment by more than employment on impact and vice versa for $\lambda > 0.5$.

4 Results

With these restriction at hand, 1.000 draws are collected, accounting for estimation uncertainty (by sampling $\mathbf{a}$ and $\mathbf{\Sigma_u}$) and model uncertainty (by sampling $\mathbf{Q}$ for a given $\{\mathbf{a}, \mathbf{\Sigma_u}\}$

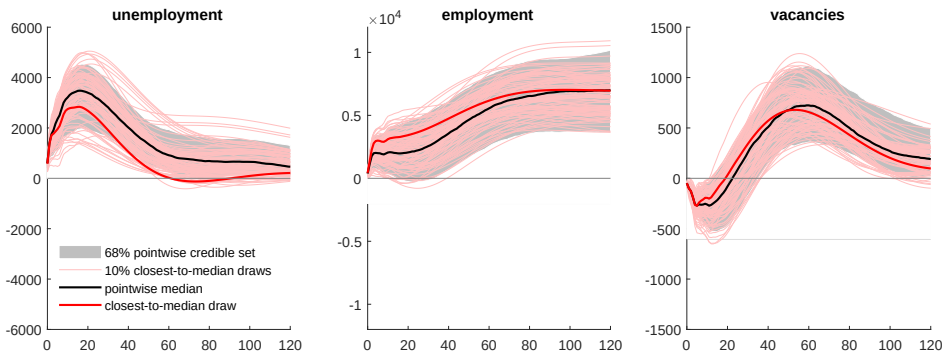

Figure 3: Impulse responses to a labor supply shock

pair)[4]. Figure 3 presents impulse responses to a labor supply shock over a horizon of ten years and according to various measures used in the literature[5]. The black solid lines represent the pointwise medians, which is an intuitive summary measure but does not come without problems when a set-identification procedure such as sign restrictions is used, as it mixes various $\mathbf{B^{-1}}$ and, hence, various structural models. A measure that copes with this issue is the one proposed by Fry and Pagan [2011]. It amounts to choosing the model with impulse responses closest to the pointwise median. To make responses comparable across impulses and variables, they are standardized according to

$$\tilde{\phi}_{j\times k,t} = \frac{\phi_{j\times k,t} - med(\phi_{j\times k,t})}{std(\phi_{j\times k,0})}, \tag{12}$$

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

$$min \left(\sum_{j\times k} \sum_{t} \tilde{\phi}^2_{j\times k,t} \right). \tag{13}$$

It is represented by the red solid lines in figure 3. The 68% pointwise credible set (gray shaded areas) is often presented along with the pointwise median and, hence, suffers from the same shortcoming. The set of 10% (i.e. 100) impulse responses that come closest to the pointwise

[4]Only about 5-10 $\mathbf{Q}$'s out of 100.000 obey the restrictions for a given $\{\mathbf{a}, \mathbf{\Sigma_u}\}$ pair. The low size of admissible models is entirely due to the almost-equality-restriction on the coefficients representing θ, while the pure sign restrictions are much "weaker". The θ-restriction reduces the ranges of impulse responses and provides an economically reasonable pattern to the response of vacancies to labor supply shocks.

[5]Impulse responses to the other shocks along the Beveridge Curve, c, and other shifters of the Beveridge Curve, s, are not discussed here, but they are available upon request.

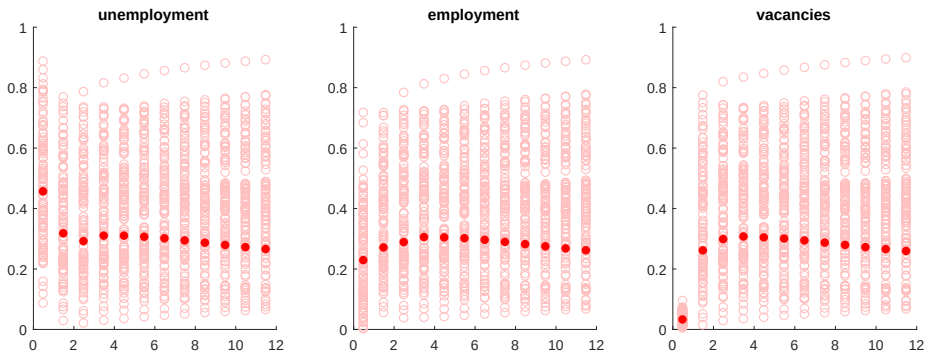

Figure 4: Forecast error variance contribution of labor supply shocks

median spans a similar range as the 68% pointwise credible set, so I will use it as an alternative credible set in the remaining analysis.

The results are revealing. Unemployment rises in the first year of the labor supply shock, as there are more job seekers on the labor market and it takes longer for existing job seekers (unemployed) to be matched to a vacancy. Thereafter higher unemployment is abating gradually, but it hardly declines below its pre-shock level. As the unemployment effect abates, the positive effect to employment is enhanced. A higher long-term level of employment reflects the extension of the labor force. Remember that the impact response of vacancies to labor supply shocks is not restricted in any way. While the effect is small it is clearly negative for almost all draws, which means that the effect of increased matching (depressing the vacancies stock) dominates the effect of lower recruitment costs (incentivizing vacancy creation) in the first months after the shock. This reverses after 1 to 3 years and the number of vacancies increases above its pre-shock level. The medium-term acceleration of the employment surge is complementary to that as it takes more vacancies to foster employment. When the higher long-term path of employment is attained around 6 years after the shock, new job openings bounce back to their pre-shock level. The unambiguous impact response of vacancies to labor supply shocks is surprising given that no sign restrictions are imposed and that, generally, identification by sign restrictions is known to be "weak" [Canova and Paustian, 2011, Paustian, 2007]. In fact, the impulse responses are significantly sharpened by the equality restriction imposed on the coefficients that represent θ in the impact multiplier matrix $\mathbf{B}^{-1}$. This restriction shrinks the admissible parameter space to economically reasonable values (see footnote 4).

Figure 4 presents the forecast error variance contributions of labor supply shocks over the first 12 months for the model with impulse responses closest to the median and the respec-

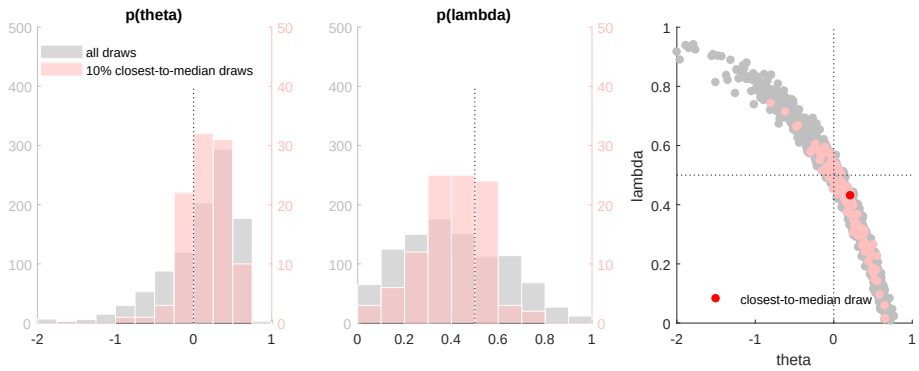

Figure 5: Impact elasticities

tive credible set. An intriguing result is that all draws indicate that the explanatory power of labor supply shocks for vacancies is virtually absent on impact, but that this changes quickly for most of the draws. From the second month onwards the models are much more ambiguous about the contribution of labor supply shocks to the variance of vacancies. Another result is that the contribution of labor supply shocks to unemployment declines after the month of impact. According to the model with impulse responses closest to the pointwise median, labor supply shocks explain approximately a third of the variation of all three variables.

Figure 5 presents the empirical distributions of the estimated impact elasticities θ and λ discussed in the previous section. Remember that θ constitutes the labor supply elasticity with respect to employment and λ represents the employment elasticity with respect to labor supply shocks. Distributions are presented for all 1.000 draws and for the set of 100 draws with impulse responses closest to the median. One might expect θ to lie between zero and one, implying that some workers who lose their job move out of labor force (discouraged-worker effect) and that some vacancies are filled from out of the labor force. $\theta > 1$ is ruled out by the sign restrictions, as it would imply procyclical unemployment. Indeed, even $\theta > 0.75$ is not recovered by any model. The majority of draws, and two thirds of the closest-to-median draws find $0 < \theta < 0.5$. While the economically reasonable upper limit of one holds by construction, there is no *lower* bound to θ. Indeed, some draws recover a θ smaller than zero. This seemingly odd result has also been observed in US data [Elsby et al., 2015a]. It implies that the countercyclical unemployment response is *enhanced* by the endogenous labor force reaction. A way to rationalize this result is through a heterogeneous worker effect. Some workers are more attached to their firm, some are less attached. The former have a lower risk of losing their job but if they do (e.g. in deep recessions) they have a lower propensity to move out of labor force. However, even if there is such a heterogeneous worker effect in-

ducing a countercyclical movement of the labor force, it is far from clear that it dominates the effects that contribute to a procyclical movement of the labor force such as a discouraged-worker effect or different thresholds of labor market tightness at which individuals start to search for a job. Figure 5 highlights that the Fry-Pagan method adopted to shrink the admissible models to a credible set indeed favors models with $0 < \theta < 0.5$ at the expense of models with $\theta << 0$. Put differently, for models with impulse responses closer to the pointwise median it is less likely to recover $\theta << 0$ than for models at the edges of the distribution. Models with $0 < \theta < 0.5$, in turn, have a higher prevalence in the credible set than in the full sample.

The impact employment elasticity of labor supply shocks λ lies in the range of zero and one by construction, because the impact responses of *une* and *emp* to labor supply shocks (the sum of which constitutes the denominator of λ) have the same sign. The majority of draws find $\lambda < 0.5$. This means that on impact, a labor supply shock raises unemployment by more than employment. Moving from the full sample to the credible set reduces the variance of this distribution and raises its mean. Models that recover λ to lie between 0.3 and 0.6 constitute three quarters of the models in the credible set. A scatter plot reveals the negative correlation between θ and λ. The higher the θ identified by a model, the lower the recovered λ and vice versa. Indeed, θ and λ are two sides of a coin, which is the unconditional correlation between employment and the labor force (or, equivalently, unemployment). θ captures causality from the former to the latter, while λ captures causality from the latter to the former. For the draw with impulse responses closest to the pointwise median, $\theta = 0.215$ and $\lambda = 0.430$.

5 Counterfactual analysis

The locus in the Beveridge Space has moved considerably to the upper right in recent years. It did not do so immediately, however. An initial rightward movement ended abruptly in mid-2015, it 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 periods of interest, I decompose the variables according to the contribution of each shock k to variable j in period t,

$$y_{j,t} \approx c_k + \sum_{i=0}^{t-1} \phi_{j \times k,i} w_{k,t-i}. \tag{14}$$

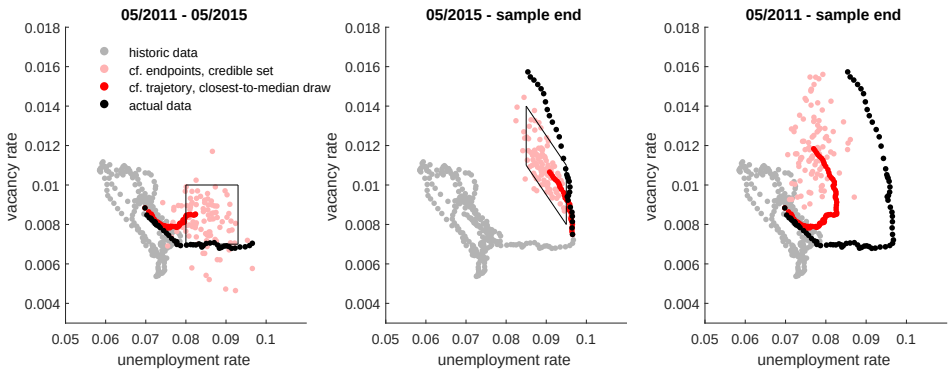

Figure 6: Counterfactual Beveridge Curves due to labor supply shocks

The counterfactual unemployment and vacancy *rates* are constructed analogously to their real-data counterparts. The counterfactuals for labor supply shocks presented in figure 6 show that a considerable share of the rightward movement of the Beveridge Curve in the period $05/2011 - 05/2015$ can be attributed to labor supply shocks. The models in the credible set spanned by the rectangle (i.e. disregarding "outliers") attribute 1 to 2.2 percentage points of the increase of the unemployment rate to labor supply shocks, which amounts to 37%-82% of its total increase (from 7% to 9.7%). The effect on the vacancy rate is inconclusive for this period, with some models pointing to an increase, some to a decrease due to labor supply shocks. The trajectory of the model with impulse responses closest to the pointwise median reveals the mechanism behind this result. Labor supply shocks first dampen the vacancy rate due to increased matching and a decline of hires. Subsequently, the vacancy rate increases. The duration of the dampening effect varies across models from less than 1 to up to 3 years (see the discussion of impulse responses in the previous section). Hence, if the positive labor supply shock was restricted to 05/2011, the vacancy rate would lie *unambiguously* above the starting values 4 years later. The fact that the results are mixed indicates that positive labor supply shocks hit the economy beyond 05/2011. This is very likely: First, because it took longer than one month for the shock to unfold, i.e. job-related immigration caused by the liberalization of labor market access was heightened for several months. Secondly, in January 2014 there was another, albeit smaller liberalization step (towards Romania and Bulgaria) which constituted a further labor supply shock.

In mid-2015 the rightward shift of the Beveridge Curve halted and a stark upward movement set in. Again, a large part of it can be explained by the forces of labor supply shocks. By then, the creation of new vacancies fueled employment growth and reduced the increased stock of unemployment by 0.2 to 1.2 percentage points. The vacancy rate was lifted by 0.15 to 0.7 percentage points. The effects exhibit an interesting dependency, indicated by the

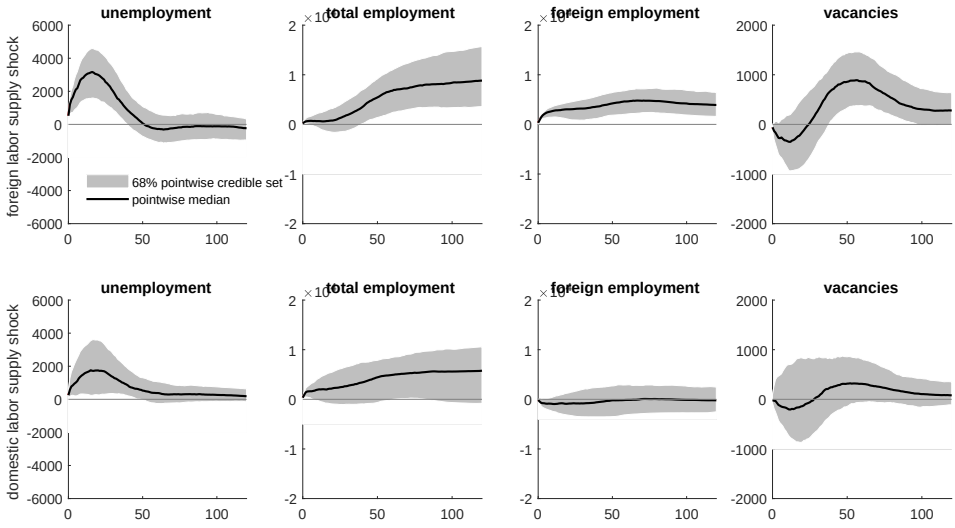

Figure 7: Impulse responses to different labor supply shocks

trapezoid shape of the space spanned by them: The higher the creation of vacancies (and, hence, of jobs) identified by a model, the higher the reduction of unemployment (via increased matching).

6 Foreign workers

So far, I have argued that a considerable share of the outward shift of the Beveridge Curve in recent years can be attributed to labor supply shocks and that the latter intensified since labor market access was liberalized for certain groups of foreign workers. Monthly data on foreign employment dating back to 1970 (available upon request) enables me to investigate this hypothesis by distinguishing labor supply shocks caused by domestic workers from labor supply shocks caused by foreign workers[6]. The identification assumption is in the vein of Furlanetto and Robstad [2016], 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 the *ratio* leaves the direction of the absolute response unrestricted, i.e. domestic employment might well *increase* in response to a supply shock of foreign workers, but the increase must be smaller than the increase of foreign employment.

[6]Examples of domestic labor supply shocks include, among others, changes towards the attitude to wage-work, in particular among women, pension reforms and school reforms, such as e.g. the extension of compulsory schooling from 8 to 9 nine years in 1966/67.

$b_{ij} \in \mathbf{B}^{-1'}$	*une*	*emp*	*f.emp*	*vac*
foreign labor supply shock	+	+	+	
domestic labor supply shock	+	+	$< \left(b_{13} \cdot \frac{b_{21}+b_{22}}{b_{11}+b_{12}} \right)$	
shock of the BC	+	−	−	+
shock along the BC	+	−	−	−

Table 2: Impact sign restrictions, 4-dim. VAR

The set of sign restrictions, given in table 2, rests on the following assumptions:

1. Potential substitution effects are, on impact, restricted to the size of the incoming labor force. This follows from the assumption that both foreign-worker and domestic-worker supply shocks raise total employment on impact. For example, if a supply shock amounts to 500 foreign workers, the stock of domestic workers cannot decline by more than 500.

2. Foreign employment may rise in response to a domestic-worker supply shock, but by less than in response to a foreign-worker supply shock. Domestic employment may rise in response to a foreign-worker supply shock, but by less than in response to a domestic-worker supply shock.

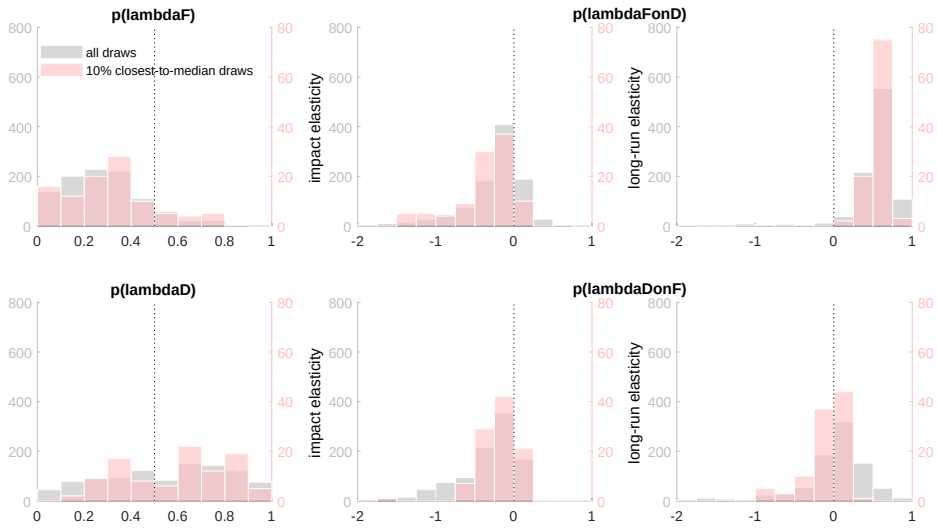

Figure 8: Elasticities, 4-dim. VAR

The results for impulse responses enrich the findings of the three-dimensional model by some intriguing aspects (figure 7). First, both kinds of labor supply shocks lead to similar re-

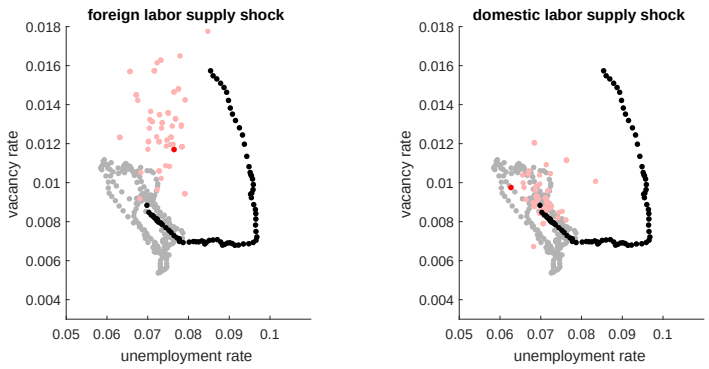

Figure 9: Counterfactual Beveridge Curves due to labor supply shocks, 4-dim. VAR

sponses of unemployment, while in terms of employment there are nuanced differences. Domestic-worker supply shocks induce a smooth increase of employment over time, shocks due to foreign workers have only a muted impact on total employment in the first months. The significant rise of foreign employment implies an initial displacement effect on domestic labor (it takes longer for domestic job seekers to be matched to a vacancy). However, in the medium run the employment surge accelerates, which affects domestic workers to a major extent, as foreign employment rises only a little beyond its initial hike. This means that the displacement effect in the short run is turned into a complementary effect in the medium run.

Figure 8 makes the interplay between domestic-worker and foreign-worker supply shocks and domestic and foreign employment even clearer. The mid column indicates that impact displacement effects are similar for both shocks: Most of the models identify modest replacement effects on impact, on domestic workers in case of foreign-worker supply shocks, and on foreign workers in case of domestic-worker supply shocks. A minority of models indicate complementary effects on impact. However, in the long run (after ten years, right column in figure 8), the effects of foreign-worker supply shocks on domestic labor is unambiguous and positive, while domestic-worker supply shocks have only small effects on foreign labor that are not clear-cut. Finally, two further aspects are worth mentioning. First, low impact employment elasticities with respect to labor supply shocks are predominantly due to shocks emanating from *foreign* workers (figure 8, left column). Secondly, also the response of vacancies to labor supply shocks seems to be driven by *foreign* workers, as the vacancy response to domestic-worker supply shocks is rather inconclusive (figure 7, lower right graph). This result might be driven by 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. As labor immigrants are lower skilled than domestic workers on average, foreign job seekers might be more likely matched to reported vacancies, while

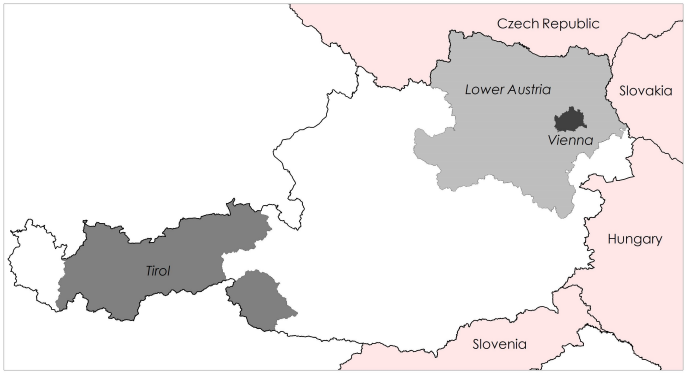

Figure 10: Map of Austria

domestic job seekers might be more likely matched to non-reported vacancies.

Figure 9 corroborates that the movement in the Beveridge Space that was induced by labor supply shocks since mid-2011 was indeed due to foreign-worker supply shocks, as the overwhelming majority of draws in the credible set indicates virtually no impact of domestic-worker supply shocks in this period. To summarize and interpret the results obtained in this section, foreign-worker supply shocks have a greater *structural* impact on the economy than domestic-worker supply shocks. They create more disorder on the labor market with more unemployment on impact, which might induce adjustment effects in production that deliver long-term gains, also in terms of domestic employment.

7 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: i.e. larger effects in the east and smaller effects in the west. Monthly data on employment, unemployment and vacancies for Austria's regions dating back to 1964 (available upon request) enables me to investigate this presumption. In this section the results for three different regions are presented: Tirol in the west of the country and Vienna and Lower Austria, which are both located in the east (figure 10). All three of these regional labor markets exhibit a counterclockwise outward movement of their Beveridge Curves, albeit with different trajectories (figure 11). Vienna experienced a large increase of unemployment from a level that was already higher than that in the other regions, but it saw only a mild increase of vacancies. Tirol, on the other hand, experienced a modest increase of unemployment, which was even more than undone by the subsequent drop, but

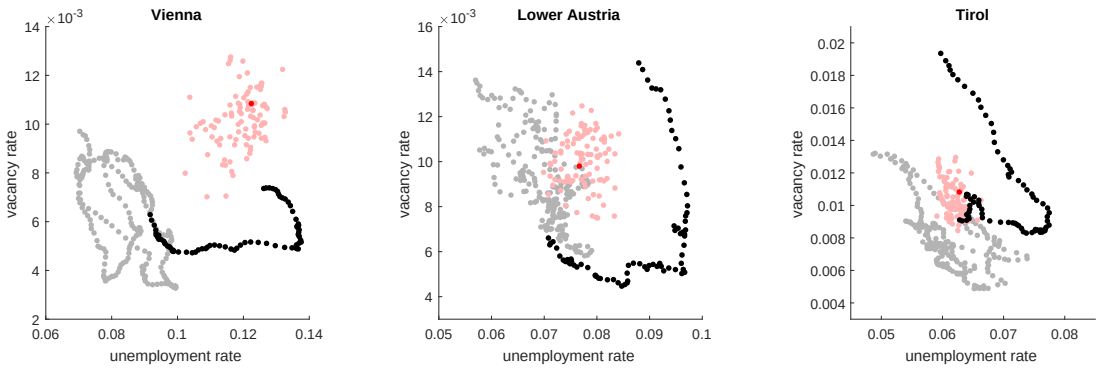

Figure 11: Results for Vienna, Lower Austria and Tirol

there was a rather pronounced surge of vacancies. Lower Austria lies somewhere in between with a substantial rise of both unemployment and vacancies, and the shape of the trajectory is closest to the federal average.

Not only do the outward trajectories differ across regions, the estimated effects of labor supply shocks display considerable differences, too; first of all with respect to size: They are large in Vienna, modest in Lower Austria and practically absent in Tirol. It corroborates the presumption that regions that are located in the east were more exposed to recent labor immigration shocks than Tirol in the west. For Lower Austria all models in the credible set indicate an outward shift of the Beveridge Curve due to recent labor supply shocks, but not for Tirol. There, some increase of the vacancy rate can be accounted for by labor supply shocks, but the unemployment rate did not react at all or it was even slightly dampened. These results suggest that geographical proximity is indeed an important factor, which may not come as a surprise, as Lower Austria and Vienna are so close to the east neighboring countries that migrant workers can commute (profiting from both higher wages and lower living costs). The differences between Vienna and Lower Austria regarding the size of the effects point to another dimension that might be important in this regard, as there is no difference between them with respect to the geographical location. This dimension might be urbanity. Vienna is a metropolis, while Lower Austria is predominantly rural, similar to Tirol. In Vienna, the surge of the unemployment rate by 3-4 percentage points was entirely driven by labor supply shocks according to the majority of draws in the credible set[7].

[7] In Vienna, labor supply shocks also exerted a strong effect on vacancy creation, to which the number of realized vacancies lags behind. In Tirol, on the other hand, the realized number of job postings is larger than what is implied by labor supply shocks. This could be due to other idiosyncratic shocks in these regions. But it could also result from geographical mismatch *across* regions, which cannot be captured properly as a Beveridge Curve shifter in regional estimations, as unemployment and vacancies rise in different regions.

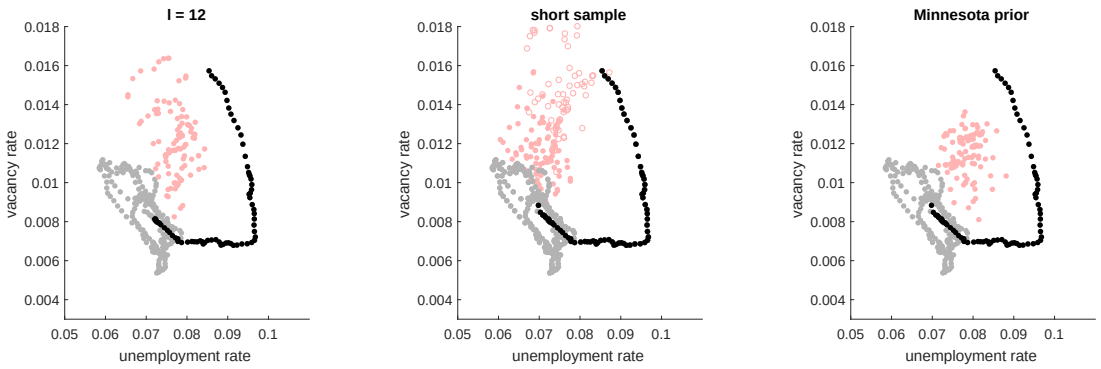

Figure 12: Counterfactual Beveridge Curves, alternative specifications

8 Robustness

The main finding of the paper, the considerable contribution of (foreign) labor supply shocks to the counterclockwise outward shift of the Beveridge Curve, is robust to the choice of lag length l, to the choice of the sample period and to the choice of the prior.

One could presume that a model with $l = 6$ lacks information on higher lags, in particular the annual dimension. This is not the case, as incorporating year-on-year information by extending the lag order to $l = 12$ does not alter the set of counterfactual endpoints in the credible set considerably (figure 12, first graph). One could also argue that the economy changed considerably since the 1960s and by that the parameters of the model. I therefore split the sample and rerun the estimation on the second half (1989-2017). The filled dots in the second graph of figure 12 are located more to the west. The unfilled dots represent the contribution of labor supply shocks *plus* deterministic trends and they move the counterfactual endpoints to the upper east. In the short sample, more variation in unemployment and vacancies is soaked up by deterministic trends than in the full sample, not by other shocks.

As a third exercise I replace the Normal-Wishart prior on the reduced-form coefficients by a Minnesota prior. The Minnesota prior shrinks the VAR estimates towards a multivariate random walk, which is a reasonable assumption for the variables at hand. Prior variances of the coefficients are given by

$$v_{mn,i} = \begin{cases} \left(\frac{\delta}{i}\right)^2 & \text{for } m = n \\ \left(\frac{\eta\sigma_m}{i\sigma_n}\right)^2 & \text{for } m \neq n \end{cases} \tag{15}$$

where δ is the prior standard deviation of $a_{mm,1} \in \mathbf{A_1}$ and $\eta\frac{\sigma_m}{\sigma_n}$ is the prior standard de-

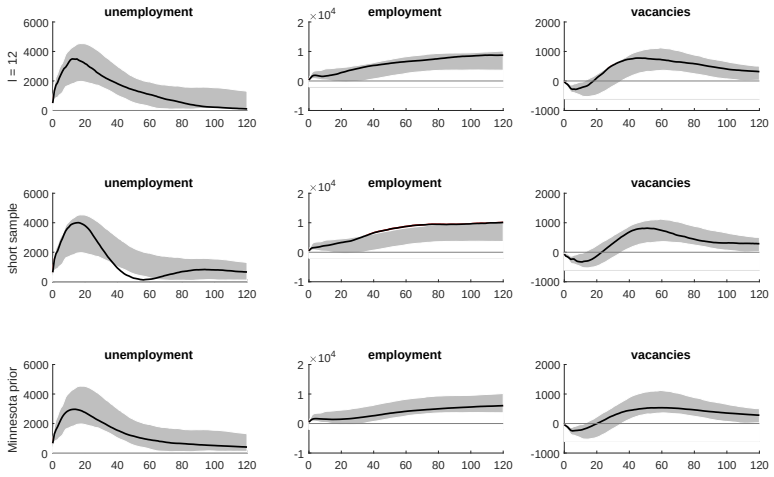

Figure 13: Point-wise median impulse responses for alternative specifications together with 68% point-wise credible set of the baseline specification

viation of $a_{mn,1} \in \mathbf{A_1}$. These prior variances on lagged coefficients decrease quadratically with increasing l (i.e. posterior means are shrunk to zero), as the prior belief in insignificance is proportional to the lag order. I choose relatively large prior variances $\delta = \eta = 1$. The prior on the deterministic terms is flat, with mean zero and variance 100. The credible set of counterfactual endpoints is more compact than with the Normal-Wishart prior. The cloud is located to the upper east of the historic Beveridge Curve, corroborating a significant contribution of labor supply shocks to its outward shift in recent years.

The robustness of the results to these alternative specifications is not only established in terms of counterfactuals, but it is also corroborated in terms of impulse responses: The impulse responses share the same properties as in the baseline specification and the point-wise medians are reasonably covered by the 68% point-wise credible set of the baseline specification (figure 13).

9 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 to a large extent from job-related migration. European integration has fostered labor migration, since free movement is one of the core principles of the EU treaty, entailing free movement of labor. Labor market integration gained momentum in mid-2011, when Germany and Austria granted this principle

to those Central and Eastern European countries that joined the European Union in 2004. I study the effects on Austria, which was particularly affected due to its geographical position and high income gap towards these countries, and show that the marked outward shift of the Beveridge Curve is related to labor supply shocks due to job-related immigration. However, the counterclockwise movement induced by labor supply shocks in the Beveridge Space is not yet complete. While the outward shift might last for several years, it will ultimately reverse as unemployment and vacancy rates will move back (close) to their pre-shock levels. In the long run, the economy is off with a higher employment level, including domestic workers, which suggests that foreign and domestic labor is complementary. In the short and medium run, however, labor supply shocks caused by foreign workers churn labor markets and the burden of adjustment might be spread unevenly across the destination country. For example, Vienna was much more exposed to job-related immigration than other regions, so it has to cope with heightened unemployment for several years. Thus, policy measures that affect labor migration should be considered carefully and their implementation should be well monitored. In particular, shifts of the Beveridge Curve due to labor supply shocks should not be mistaken for shifts arising from structural impediments in the labor market (e.g. a deterioration of matching efficiency), as their roots are quite different and they require different policy responses.

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