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Immigration and the Macroeconomy: Some New Empirical Evidence.*

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Abstract

We propose a new VAR identification scheme that enables us to disentangle immigration shocks from other macroeconomic shocks. Identification is achieved by imposing sign restrictions on Norwegian data over the period 1990Q1 - 2014Q2. The availability of a quarterly series for net immigration is crucial to achieving identification. Notably, immigration is an endogenous variable in the model and can respond to the state of the economy. We find that domestic labor supply shocks and immigration shocks are well identified and are the dominant drivers of immigration dynamics. An exogenous immigration shock lowers unemployment (even among native workers), has a positive effect on prices and on public finances in the medium run, no impact on house prices and household credit, and a negative effect on productivity.

Keywords: labor supply shocks, immigration shocks, job-related immigration, identification, VAR.

J.E.L. Codes: C11, C32, E32.

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1 Introduction

During the past decades immigration flows have increased significantly in most advanced economies. This is certainly the case for Norway, where the population share of immigrants has increased from approximately 3.5 percent in 1990 to over 12 percent in 2014. While a large literature has studied in detail the effects of immigration flows on employment and wages using mostly disaggregate data, the impact of immigration on standard macroeconomic variables has not been investigated systematically. This paper aims at filling this gap. We conduct our analysis using Norwegian data as Norway is one of the few countries for which a quarterly net immigration series is available from the early 1990s.

Our goal is to include a net immigration variable into a Vector Autoregression (VAR) model, which is the most widely used empirical model for macroeconomic analysis. Notably, immigration is a fully endogenous variable in our set-up and responds to exogenous immigration shocks but also to a series of macroeconomic disturbances driving the business cycle. Following the seminal contributions of Canova and De Nicoló (2002), Faust (1998), Fry and Pagan (2011), Peersman (2005) and Uhlig (2005), our identification strategy is based on imposing a limited number of sign restrictions on macroeconomic variables to disentangle immigration shocks from other sources of business cycle fluctuations. Our main contribution is to investigate the impact of immigration shocks on selected variables that we leave unrestricted in the estimation, such as unemployment, a measure of the state of public finances, house prices, household credit growth, prices and exchange rates and a measure of productivity. Furthermore, we are able to quantify the relative importance of immigration shocks for macroeconomic dynamics and evaluate the strength of the endogenous response of immigration to the other shocks identified in our system.

As already anticipated, our analysis is feasible since Norway is one of the few countries for which a quarterly net immigration series is available from the early 1990s. This series, plotted in Figure 1, is provided by Statistics Norway and has been used by Gjelsvik, Nymoen and Sparrman (2015) to analyze the impact of immigration on the wage formation system. We include in our analysis only the net flow of workers immigrating to Norway from EU/EFTA countries, North America, Australia, New Zealand and Eastern Europe

in percent of the population aged 15-74. We exclude from our analysis immigrants from Africa, Asia (including Turkey) and South and Central America since our identification assumptions are most likely violated for immigrants that do not enter rapidly into the labor force (as is the case for asylum seekers, for example). The case of Norway is particularly interesting as immigration was a marginal phenomenon in the 1990s (cf. Figure 2), whereas it became the dominant driver of population growth in the aftermath of the EU enlargement to include Eastern European countries (cf. Grangård and Nordbø, 2012). In addition, Norway is an interesting laboratory to disentangle the immigration shock from two other labor market shocks. The first is a domestic labor supply shock that turns out to be particularly important, as participation is cyclical and volatile in Norway. The second is a wage bargaining shock that may have a structural interpretation in Norway given the centralized nature of the wage negotiation system (cf. Aukrust, 1977), in which the wage norm is determined in the sector exposed to international competition (wage leader) and is then used to guide wage increases in the other sectors of the economy (wage followers).

We disentangle the three labor market shocks (wage bargaining, domestic labor supply and immigration shocks) from business cycle shocks by assuming that they imply a negative co-movement between output and real wages. Our assumption finds theoretical support in recent macroeconomic models (cf. Galí, Smets and Wouters, 2011, and Foroni, Furlanetto and Lepetit, 2015) and empirical support in studies investigating the impact of immigration in Norway (cf. Bratsberg and Raaum, 2012, and Bratsberg, Raaum, Røed and Schøne, 2014). To identify the wage bargaining shock we use data on the participation rate and assume that a wage bargaining shock that lowers the real wage also reduces the participation rate. Whereas to disentangle domestic labor supply shocks from immigration shocks we rely on a restriction on the ratio of immigrants over participants that is naturally pro-cyclical in response to an expansionary immigration shock and counter-cyclical in response to an expansionary domestic labor supply shock. In addition to the three shocks originating in the labor market, our baseline set-up includes a business cycle shock that moves output and real wages in the same direction and that is supposed to

capture shocks that do not originate in the labor market (such as demand shocks, oil shocks and productivity shocks).

This set-up allows us to quantify the importance of immigration shocks for business cycle fluctuations and to discuss the endogenous response of immigration to other shocks. We estimate several versions of our baseline model introducing one alternative unrestricted variable in each experiment. This strategy enables us to investigate the macroeconomic effects of immigration shocks on variables such as unemployment, public finances, house prices, household credit, prices, exchange rates and productivity. The analysis of the drivers of immigration and the effects of immigration shocks on macroeconomic variables constitute the key contributions of this paper.

In terms of impulse responses, several results emerge from our analysis. First, an exogenous increase in immigration lowers the unemployment rate and even the unemployment rate for native workers. Second, a positive immigration shock increases public spending in the medium run, but the response of fiscal revenues follows the same path and the net effect on public finances turns out to be even positive in the short run and neutral in the long run. Third, the immigration shock has no effect on house prices, which are mainly driven by business cycle shocks, but also by domestic labor supply shocks that generate a negative conditional correlation between house prices and immigration. Thus, if anything, immigration has had a mitigating effect on the housing boom that Norway has experienced in our sample period. The same result is confirmed when we consider household credit growth. Fourth, an expansionary immigration shock has no effect on domestic prices but results in an increase in the CPI in the medium run through an exchange rate depreciation. Fifth, labor productivity falls in response to an immigration shock.

In terms of variance decompositions, our main result is that immigration shocks are non-negligible (although not major) drivers of the Norwegian business cycle, explaining on average around 15-20 percent of output fluctuations. Immigration responds little to the state of the business cycle in Norway, whereas it reacts more to factors that are specific to the Norwegian labor market: when participation by native workers is low (i.e. in response

to a negative domestic labor supply shock), immigration increases significantly.

The literature on immigration in the context of standard macroeconomic models is surprisingly limited, perhaps due to the absence of reliable quarterly series for net immigration over a sufficiently long period for many countries. Mandelman and Zlate (2012) propose a dynamic stochastic general equilibrium (DSGE) model with immigration focusing on the role of remittances for business cycles in Mexico. Earlier contributions include Canova and Ravn (1998), who study the macroeconomic impact of a flow of unskilled migrants in the neo-classical growth model, and Bentolila, Dolado and Jimeno (2008), who show how immigration affects the slope and the intercept of the New Keynesian Phillips curve. In the VAR literature, Kiguchi and Mountford (2013) provide an analysis on US annual data using the penalty function approach in which a shock to the working population (that could be due to immigration but also to domestic factors) leads to a temporary reduction in GDP and consumption per capita. D'Albis, Boubtane and Coulibaly (2015) use monthly data for France over the sample period 1994-2008 in a VAR identified with a recursive scheme. They find that immigration responds significantly to France's macroeconomic outlook and at the same time immigration itself increases GDP per capita, particularly in the case of family immigration. The closest papers to our analysis are two recent and interesting analyses on New Zealand data. In the first, McDonald (2013) studies the effect of an immigration shock on house prices in a VAR identified with a recursive scheme. He shows that an immigration shock has a strong positive effect on house prices and construction activity, thus boosting aggregate demand even more than aggregate supply. The second paper, Armstrong and McDonald (2016), extends the previous set-up to include a second immigration shock associated with fluctuations in Australian unemployment. They find that higher net immigration due to a higher Australian unemployment rate leads to a higher unemployment rate in New Zealand, whereas higher net immigration for other reasons reduces unemployment in New Zealand. Our contribution to this previous literature is the identification of an immigration shock that is distinct from other shocks using a minimum amount of sign restrictions.

While we could find only a few DSGE and VAR studies on the macroeconomic ef-

fects of immigration, the literature using more disaggregate data is extremely rich (for a survey cf. Kerr and Kerr, 2011, and Hagelund, Nordbø and Wulfsberg, 2011). Selected issues of interest are the assimilation of immigrants into the host-country labor market in terms of wages and employment, the identification of displacement effects on native workers in terms of wages and employment (cf. Friedberg and Hunt, 1995, and Borjas, 2003, among many others), the impact of immigration on public finances (cf. Borjas, 1999, Preston, 2014, Storesletten, 2000, among others), on house prices (cf. Saiz, 2003, Ottaviano and Peri, 2006, Nordbø, 2013, and Sá, 2014, among others), on prices and the composition of demand (cf. Lach, 2007, Cortes, 2008, and Frattini, 2008, among others) and on productivity (cf. Peri, 2012). While we impose as an identification assumption that an immigration boom has a dampening effect on wages (in keeping with the empirical evidence for Norway), our set-up can shed light on all the macroeconomic issues listed above in the context of an aggregate time-series approach that is complementary to analysis based on more disaggregate data and with a microeconomic focus. Notably, the main advantage of a macroeconomic approach based on sign restrictions over alternative approaches is the ability to disentangle the exogenous and the endogenous component of immigration.

The paper is structured as follows. Section 2 presents the VAR model and describes the identification strategy. In Section 3 we propose results for our baseline case with unemployment introduced as an unrestricted variable in the system. Section 4 presents several extensions to discuss the effects of immigration shocks on public finances, house prices, household credit, prices, exchange rates and productivity. Finally, Section 5 concludes.

2 The VAR model and the identification strategy

We start from the standard reduced-form VAR representation:

$$y_t = C_B + \sum_{i=1}^{P} B_i y_{t-i} + u_t, \tag{1}$$

where y_t is an $N \times 1$ vector containing our N endogenous variables, C_B is an $N \times 1$ vector of constants, B_i for $i = 1, ..., P$ are $N \times N$ parameter matrices, with P the maximum number of lags we include in the model (5 in our specific case), and u_t is the $N \times 1$ one step ahead prediction error with $u_t \sim N(0, \Sigma)$, where Σ is the $N \times N$ variance-covariance matrix.

Given the large number of parameters to be estimated, we use Bayesian methods. Moreover, the model is specified and estimated with variables in levels, as the Bayesian approach can be applied regardless of the presence of non-stationarity (cf. Sims, Stock, and Watson, 1990, for more details on this point). We specify diffuse priors so that the information in the likelihood is dominant. These priors lead to a Normal-Wishart posterior with mean and variance parameters corresponding to the OLS estimates. To obtain identification via sign restrictions, we follow the procedure described in Rubio-Ramirez, Waggoner and Zha (2010). Additional details about the estimation procedure are provided in Appendix A1.

In order to map the economically meaningful structural shocks from the reduced form estimated shocks, we need to impose restrictions on the estimated variance-covariance matrix. In detail, the prediction error u_t can be written as a linear combination of structural innovations ϵ_t

$$u_t = A\epsilon_t$$

with $\epsilon_t \sim N(0, I_N)$, where I_N is an $(N \times N)$ identity matrix and where A is a non-singular parameter matrix. The variance-covariance matrix has thus the following structure $\Sigma = AA'$. Our goal is to identify A from the symmetric matrix Σ, and to do that we need to impose restrictions. Those restrictions are imposed only on impact, following the recommendation of Canova and Paustian (2011), and are sufficient to disentangle four identified shocks (one general business cycle shock and three shocks originating in the labor markets) and a fifth shock that captures the residual dynamics in the system.

In our baseline estimation exercise we include five series: GDP for mainland Norway (thus excluding petroleum and ocean transport activities, as is standard in all macroeconomic analysis for Norway), the series for real wages (defined as nominal wage costs

per hour deflated by core CPI), the participation rate from the labor force survey, the immigration rate series (including only the stock of immigrants living in Norway from EU/EFTA countries, North America, Australia, New Zealand and Eastern Europe in percent of the population aged 15-74) derived from the net immigration series provided by Statistics Norway and the unemployment rate from the Norwegian Labor and Welfare Administration (NAV). A detailed description of the dataset is presented in Appendix A2. The sample period is 1990 Q1-2014 Q2.

The impact restrictions imposed in our baseline model are summarized in Table 1.

Table 1: Impact restrictions in the baseline model

	Business Cycle	Wage Barg.	Dom. Labor Supply	Immigration
GDP	+	+	+	+
Real Wages	+	-	-	-
Participation Rate	+	-	+	+
Immigrants/Participants	NA	NA	-	+
Unemployment Rate	NA	NA	NA	NA

The business cycle shock is defined as a shock that moves output, real wages and the participation rate in the same direction. Its interpretation as a generic business cycle shock relies on the fact that both real wages and the participation rate are pro-cyclical in Norway. It is supposed to capture shocks originating in the oil sector (cf. Bjørnland and Thorsrud, 2016), different kinds of demand shocks (such as government spending shocks and monetary policy shocks) and to some extent also technology shocks (although the response of participation to technology shocks is model-dependent, cf. Christiano, Eichenbaum and Trabandt, 2015).

The three remaining shocks originate in labor markets: a wage bargaining shock and two labor supply shocks, one domestic and one driven by exogenous immigration flows.

The wage bargaining shock is defined as a shock that generates countercyclical dynamics in real wages and in the participation rate. These restrictions find strong theoretical support in a New Keynesian model with search and matching frictions and endogenous labor force participation, as discussed in Foroni, Furlanetto and Lepetit (2015), but also in the model of unemployment proposed by Galí, Smets and Wouters (2011). Notice that, as already mentioned in the Introduction, Norway is the ideal laboratory to study wage

bargaining shocks given its highly centralized system of wage negotiation. While this shock does not play an important role in our analysis, it allows us to introduce the participation rate into the system in a meaningful way and it guarantees that the remaining labor market shocks are not contaminated by shocks originating in the wage negotiation process (that may also capture fluctuations in unemployment benefits and in matching efficiency).

Our definition of an immigration shock is rather simple and intuitive: it is a shock that generates a positive co-movement between output and participation and a negative co-movement between output and real wages.[1]

The first assumption implies that ideally we would like to concentrate only on immigrants that enter rapidly into the labor force, irrespective of their geographical origin. However, as the quarterly immigration series from Statistics Norway is only available by country-groups, we cannot isolate job-related immigration. Nevertheless, by focusing on immigration from western countries we capture a substantial share of the recent immigration boom, which is mostly job-related (cf. Figure 1). Notably, additional *annual* data from Statistics Norway confirm that work is the major motivation for immigration from the countries included in our analysis, whereas this is not the case for the countries excluded from our analysis, as it can be seen in Table 2. Moreover, data from 2014 confirm that the immigrants included in our series have on average a higher employment and unemployment rate than natives, thus suggesting a higher participation rate. In contrast, immigrants from non-western countries exhibit an employment rate substantially lower than natives and access the country mainly via family reunification or as asylum seekers. Therefore, those immigrants may enter the labor force only with a long delay, in contrast with our identification assumption for immigration shocks.

Our second identification assumption is that an exogenous increase in immigration has a negative effect on real wages on impact. This assumption follows from a standard labor supply-demand framework in which immigrants are expected to lower the relative wages of natives and previous immigrants for whom they are close substitutes (although

[1]Note that we use the mainland real GDP series (and not the per-capita series) in the estimation. It would not be obvious to assume that a positive immigration shock increases GDP per capita.

Table 2: Immigration statistics Norway 1990-2015

	All immigrants	Included	Excluded	Natives
Work main reason	34	54	6	NA
Refugees	19	8	34	NA
Family reunification	36	30	46	NA
Other reasons (e.g education)	11	8	14	NA
Employment rate (2014)	63.4	73.0	54.5	69.4
Unemployment rate (2014)	7.1	5.8	9.1	1.5
Share of population (1990)	3.6	2.0	1.5	96.4
Share of population (2014)	12.4	7.7	5.9	87.6

Note: Included are immigrants from EU/EFTA countries, North America, Australia, New Zealand and Eastern Europe, while excluded are immigrants from Africa, Asia (including Turkey) and South and Central America. All numbers in this table are in percent

the wages of complementary workers may even increase). While those wage-mitigating effects of immigration are usually found to be small in the literature (cf. Friedberg and Hunt, 1995), more recent studies based on national labor markets for workers of different skills and work experience tend to find larger negative effects (cf. Borjas, 2003).[2] In addition, and most importantly for our purposes, two recent influential studies on Norwegian data also support our identification assumption as a sensible starting point to identify immigration shocks. Bratsberg and Raaum (2012) investigate the evolution of wages in the Norwegian construction sector over the period 1998-2005, a period of rising immigrant employment in the sector. They exploit the requirements of certifications and authorizations of skills according to national standards as a source of exogenous variation across different segments of the construction sector. In fact, those licensing requirements made it difficult for immigrants to enter some segments (like electrical installation and plumbing activities) but not others (like carpenter and painting firms). They find that a 10% increase in immigration leads to a decline in wages for native workers by 0.6%. Bratsberg, Raaum, Røed and Schøne (2014) extend the previous analysis over a longer sample period (1993-2006) and consider other sectors by using the national skill cell approach (cf.

[2]A continuing controversy on the magnitude of these wage dispacement effects is evident in the literature (cf. Card, 2005, and Borjas, 2003). Ottaviano and Peri (2012) build on the Borjas framework and extend it to estimate the elasticity of substitution across different groups of workers. They find a small and significant degree of imperfect substitutability between native and immigrant workers and conclude that the *long-run* effect on wages is small. Here, it is important to emphasize that our identification assumption relates to the *short-run* effect on wages and is imposed on *average* wages rather on *native* wages.

Borjas, 2003) on data drawn from Norwegian administrative registers. They confirm negative wage effects with a larger impact on previous immigrant wages than on native wages and with native wages responding more to inflows of immigrants from Nordic countries than from developing countries, thus reflecting a higher degree of substitutability between native and Nordic workers.

We complete the characterization of an immigration shock by including the immigration rate as a separate variable into the system and imposing a restriction on the ratio of immigrants over participants to disentangle immigration shocks from domestic labor supply shocks. Somewhat intuitively, we assume that on impact (and only on impact) an expansionary domestic labor supply shock lowers the ratio of immigrants over participants, whereas an exogenous increase in immigration increases the same ratio. Note that we are just assuming that the relative impact of an immigration shock is larger over the pool of immigrants than over the pool of participants, thus ruling out extreme shifts in the participation pattern of native citizens. Along the same lines, the response of immigration to an expansionary domestic labor supply shock is allowed to be positive or negative. If positive, however, we impose that the immigration response has to be lower than the participation response.

Finally, we include a fifth shock to match the number of shocks with the number of observables. This is a residual shock that does not satisfy the restrictions imposed on the other four identified shocks. Although it is supposed to capture only the residual dynamics in the system, the shock has an economic interpretation: it is a shock that moves output and participation in different directions and output and wages in the same direction.[3] In this way, the system is fully identified.

[3]These dynamics are generated by technology shocks in the models by Foroni, Furlanetto and Lepetit (2015) and Campolmi and Gnocchi (2015). However, participation is pro-cyclical (conditional on technology shock) in the model by Christiano, Eichenbaum and Trabandt (2015). Given these constrasting results, we refrain from a structural interpretation of the residual shock. Nonetheless, its presence in the system is useful, as it allows us to leave the fifth variable in the system completely unrestricted, arguably an important benefit of our specification.

3 Results

In this section we present results for our estimated baseline VAR model and for a series of alternative specifications.

3.1 Baseline Model

We plot in Figure 3 the impulse responses to an immigration shock in our estimated baseline VAR model. The responses of all variables are expressed in percent, except for the unemployment rate that is expressed in percentage points. An expansionary immigration shock has persistent effects on GDP, real wages, the participation rate and the immigration rate, despite only restricting the impact response for all these variables. While the expansionary effect on GDP is sizeable, the maximum effect is achieved well before the peak in the immigration response. Notably, unemployment declines on impact and more so after few quarters. This partly reflects the mechanical response due to an increase in participation, although this mechanical effect is very small. The size of the response is remarkable and may highlight some complementarities between immigrants and natives. Such an expansionary effect on unemployment is not necessarily surprising if we consider that many immigrants (in particular from Eastern Europe) come to Norway with a job offer. Notably, a decline in unemployment in response to an increase in immigration is consistent with previous estimates for the US based on a production function approach (cf. Peri, 2012).

Let us now try to interpret these dynamics. The hump-shaped response in the immigration rate may be explained by the combination of three factors. First, it may be due to registration delays. Registration is in fact mandatory only for contracts longer than six months and it is possible that many workers start working in Norway on short-term contracts (thus contributing to GDP) and only register once they obtain a longer contract. Second, the peak after ten quarters may reflect family reunifications. As we have seen in Table 2, while work is the main reason why immigrants included in our sample come to Norway, the importance of family reunifications is far from negligible. It is reasonable to think that a substantial share of these additional immigrants will not enter the labor

force, thus explaining why the immigration rate's response is more persistent than the participation rate's response. Finally, the hump-shaped response of immigration may also be explained by network effects, i.e. the fact that immigrants from the same country tend to follow each other. The establishment of large communities of immigrants from Sweden, Poland and Lithuania may also be related to these network effects, in addition of course to the role played by geographical proximity. In addition, the fact that the GDP response peaks only after 4 quarters, well before the peak in immigration, may reflect composition effects leading to a decline in productivity in the economy that may reconcile a substantial and persistent decline in unemployment with a short-lived effect on GDP. We will explore this conjecture further in the next section.

In Figure 4 we plot impulse responses to an expansionary domestic labor supply shock. The dynamics generated by this shock are similar to those generated by an immigration shock (although substantially more persistent). The important difference is that the immigration rate declines (rather than increasing) in response to a positive shock over a long horizon. The different response of the immigration rate highlights how our identification scheme is successful at disentangling these two labor market shocks.

The immigration rate responds significantly to the domestic labor supply shock but is substantially less responsive to the other three shocks (cf. Figure 5). It increases following a reduction in the bargaining power of workers and an expansionary residual shock, whereas it declines in response to a business cycle shock. However, all these effects are not statistically significant.[4] Notably, immigration exhibits a hump-shaped response to all five identified shocks, thus extending our previous discussion on delayed registration, family reunifications and network effects also of other shocks.

These results indicate that immigration responds little to the state of the business cycle in Norway (and to shocks in the wage negotiation process) whereas it reacts substantially

[4]In the Online Appendix we present all the remaining impulse responses. The wage bargaining shock is set apart from the domestic labor supply shock on the basis of the participation response, which is negative on impact and essentially flat afterwards. A decline in the bargaining power of workers lowers unemployment in keeping with the predictions of standard New Keynesian models. In the Online Appendix we also further disentangle the business cycle shock into two components: a productivity shock that moves output and prices in opposite directions and a demand shock that moves output and prices in the same direction. Our main results are confirmed in that extended set-up for which the estimation is more computationally intensive.

to domestic labor supply shocks: when participation from natives is low, immigration increases significantly. The muted response of immigration to business cycle shocks is somewhat puzzling, but may reflect the flexibility of the native labor force. In fact, the marginal participants in the native labor force, who are likely to be close substitutes for labor immigrants, increase native participation in response to a positive business cycle shock, thus possibly reducing the demand for immigrant workers. The cyclicality of native participation is enhanced by the fact that schooling is counter-cyclical in Norway.

The importance of labor supply factors for immigration dynamics emerges also from Figure 6 where we plot the variance decomposition across different horizons as derived from our model. The immigration rate is driven mainly by immigration shocks and domestic labor supply shocks. The immigration shock is also a non-negligible (although not major) driver of GDP and real wages, whereas it is even the main driver of the unemployment rate. The three labor market shocks grouped together explain an average of 50% of GDP fluctuations and account for a dominant share of unemployment fluctuations. Such an important role for these shocks is not surprising given the large number of labor market variables used as observables in the estimation.[5]

The variance decompositions for output and the labor force participation rate turn out to be rather similar, reflecting the large pro-cyclicality of participation in Norway. In contrast, the different profiles of the variance decompositions for output and unemployment (and the limited role of business cycle shocks for unemployment fluctuations) are perhaps more surprising. Those results are, however, consistent with estimates of Okun's law for Norway indicating that a decline in GDP relative to trend of 1% results in an increase in unemployment relative to trend of only 0.25 percentage points (cf. Ball, Leigh and Loungani, 2012). While unemployment is less cyclical in Norway than in other countries, our results show that the unemployment response is relatively large (and the output response is relatively limited) *conditional* on immigration shocks. This may relate to the negative response of labor productivity, which we will discuss in the next section.

[5] An important role for labor supply factors in VAR models estimated on US data has been found by Shapiro and Watson (1988), Chang and Schorfheide (2003) and Foroni, Furlanetto and Lepetit (2015). Those shocks are supposed to capture mainly demographic factors, but alternative interpretations have been discussed recently in the literature (cf. Barnichon and Figura, 2015).

3.2 Alternative specifications

A decline in unemployment in response to an exogenous increase in immigration seems to be in contrast with important displacement effects on natives. Nevertheless, it is interesting to re-estimate our model using a measure of unemployment for native Norwegians that has been available since 1995-Q1 rather than the total unemployment rate. Notwithstanding the difference in the sample period, we remark in Figure 7 that the decline in unemployment for natives is almost identical to the decline in total unemployment in our baseline model. All in all, we do not find any evidence in favor of displacement effects. In contrast, we find positive spillovers that may suggest a high degree of complementarity between domestic and foreign workers.

We now focus on a few selected results by proposing an extensive sensitivity analysis. For each case we plot in Figure 8 the response of the unemployment rate to a positive immigration shock and the variance decompositions for the unemployment rate and the immigration rate.

In a first experiment, we reconsider the horizon at which we impose the sign restrictions. In our baseline, model we impose restrictions only on impact. This assumption may be more problematic for variables featuring a high degree of stickiness, as may be the case for wages. Therefore, we check whether our main results are confirmed in a version of the model where all the restrictions on wages are imposed at horizon four (and only at horizon four). The results emerging from the baseline model are broadly confirmed in this alternative set-up, although the importance of immigration shocks for unemployment fluctuations is somewhat reduced.

In a second experiment, we use a different wage series in the estimation by focusing on wages in the construction sector. We thus impose the less restrictive assumption that only wages in the construction sector decline in response to a positive immigration shock, in keeping with the micro-evidence of Bratsberg and Raaaum (2012). Our results are basically unaffected.

In a third experiment we consider a shorter sample period ending in 2004Q1, just before the EU enlargement to include Eastern European countries. The response of un-

employment is more muted in this case and domestic labor supply shocks are the main drivers of unemployment. It is reassuring that immigration shocks are less important in this shorter sample period, as we expect a relevant role for immigration shocks precisely in the early phase of the EU enlargement.

In a final experiment, we exclude immigrants from Eastern Europe from the immigration series. The response of unemployment is unchanged in this case. Nevertheless, we note one important difference from our baseline model. The immigration variable is now driven almost exclusively by immigration shocks or, put differently, the endogenous response of immigration to domestic labor supply shocks is now minor. This hints at the possibility that the endogenous component of immigration may be driven mainly by Eastern European workers that react flexibly to the state of the labor market in Norway.

4 The impact of immigration on key macroeconomic variables

In the previous section, we studied the drivers of the immigration rate and the effect of an immigration shock with a special focus on unemployment to discuss potential employment displacement effects through the lenses of our empirical model. In this section, we offer a macro-perspective on some topics that have emerged in the more recent literature on immigration and that have so far been analyzed only in the context of microeconomic studies. In particular, we investigate the link between immigration and public finances, house prices, credit to households, prices and exchange rates, and productivity. In each experiment, we include a different unrestricted variable as the last variable in the system at the place of unemployment. The general results emphasized in the previous section are confirmed in all these alternative experiments. Therefore, the goal of the section is to discuss only the responses of the variables that are left unrestricted in the system. The results are shown in Figures 9 and 10, where in each line we present the impulse response of the variable of interest to a positive immigration shock and to a positive domestic labor supply shock together with the variance decomposition for the variable itself.

Immigration and public finances. The burden that immigrants may place on public finances is often one of the popular arguments used to oppose immigration. Social security programs in host countries (and in Norway in particular) are more generous than in immigrants' originating countries. Borjas (1999) discusses the welfare magnet effects that may attract a large pool of immigrants to countries with generous welfare systems. On the other hand, immigrants may also be net contributors to public finances, especially if young and highly educated. Storesletten (2000) finds that a reform of immigration policies alone could resolve the fiscal problems associated with the aging of the baby boom generation. In particular, he investigates feasible policies in the context of a calibrated general equilibrium model with overlapping generations and suggests the admission to the US of 1.6 million 40-44 year-old highly skilled immigrants annually.

We can investigate the impact of an immigration shock on public finances by including a measure of net fiscal revenues (defined as the difference between tax revenues and public spending) as an unrestricted variable in our system. The response of public finances to a positive immigration shock is hardly significant and, if anything, on the positive side on impact (cf. first line on Figure 9). Notice, however, that when we consider a measure of public spending in isolation, an exogenous increase in immigration leads to an impact decline in public spending followed by an increase in the medium run with a peak corresponding to the peak in the immigration response (cf. Figure 3). This medium run increase in government spending may capture the impact of family reunifications, while the short run decline may reflect reduced expenses for unemployment benefits in response to the improved state of the labor market discussed in the previous section. Notably, the impulse responses for net fiscal revenues and government spending can be reconciled only with a positive effect on tax revenues in the medium run. Thus, our result confirms previous findings emerging from the microeconomic literature: the net fiscal impact of an exogenous increase in immigration is relatively small (even slightly positive in the short run) but the effects on both public spending and tax revenues are not negligible, possibly in keeping with the effects discussed in Borjas (1999) and Storesletten (2000). Results are different in the case of an increase in immigration driven endogenously by a negative

domestic labor supply shock, which generates a negative conditional correlation between immigration and the state of public finances. In this case, however, it is reasonable to think that the worsening in public finances is driven by the decline in participation from natives, and immigration may even mitigate the negative consequences of the shock.

Immigration and house prices. Immigration booms are often associated with housing booms. McDonald (2013) finds that net migration changes imply large positive effects on house prices in a VAR identified with a recursive structure on New Zealand data. Other papers have shown that immigration has a positive impact on *average* house prices using disaggregate data from metropolitan areas (cf. Saiz, 2003, Ottaviano and Peri, 2006).[6] Our VAR is the ideal laboratory to analyze the link between immigration and house prices at the *aggregate* level by introducing house prices as an unrestricted variable in the model.

As we can see in Figure 9, according to our model, immigration shocks have no impact on house prices. Domestic labor supply shocks generate a negative conditional correlation between house prices and immigration but, as in the case of public finance, it is conceivable that the surge in immigration may mitigate the decline in house prices in response to a negative domestic labor supply shock. House prices respond strongly to the business cycle shock, and to some extent to domestic labor supply shocks whereas immigration shocks are almost irrelevant for house price dynamics, as it can be seen in the variance decomposition. More generally, we can conclude that immigration does not seem to play a big role in driving the recent housing boom in Norway. One possible explanation relates to the fact that a large share of immigrants is composed of Eastern European workers active in the construction sector. While many of these workers are unlikely to buy a house (at least in the short run), their contribution to the supply of new houses may be substantial.

Immigration and household credit growth. The connection between immigration and household credit has not been discussed in the literature to the best of our

[6]Notice that recent research has highlighted a negative impact of immigration on house prices *within* metropolitan areas in the US and in the UK due to the mobility response of the native population (cf. Saiz and Wachter, 2011, and Sá, 2014).

knowledge. Given the increasing attention devoted to household credit as an indicator of financial instability (together with house prices), we include it in one of our experiments. Note, however, that the stock of household debt is a largely predetermined variable, mainly representing credit accorded in the past and unresponsive to shocks almost by construction. In light of this observation, we use household credit in first differences as this is a good approximation for the new credit accorded in the period, a variable potentially more responsive to macroeconomic shocks. Nonetheless, we find that immigration shocks have no impact on household credit growth, unlike positive domestic labor supply shocks which have positive and persistent effects. The variable of interest is mainly driven by business cycle shocks and domestic labor supply shocks, whereas the role of immigration shocks and wage bargaining shocks is negligible, thus confirming our previous results for house prices. We conclude that the exogenous component of immigration does not pose clear challenges to financial stability, while the endogenous component of immigration (the one responding to the domestic labor supply factors) is negatively correlated with commonly used indicators of financial instability.

Immigration, prices and the exchange rate. The effect of an immigration shock on prices is not obvious. On the one hand, the wage mitigating effects of the increase in labor supply may put downward pressure on marginal costs and thus on prices, depending on the degree of price rigidity. On the other hand, the size (but also the composition) of aggregate demand for consumer goods changes with a larger population. If supply adjusts with a delay, we may expect an increase in prices. Lach (2007) explores the effects of the massive inflow of Russian Jewish immigrants into Israel during the 1990s and finds that prices of goods decreased. He attributes this result to the higher price elasticity and lower search costs of the new immigrants compared to the existing population. Cortes (2008) considers the effects on non-tradable goods and services (unlike Lach, 2007) in the US and finds a negative effect, in particular for low skill-intensive services. Frattini (2008) finds small effects on UK prices: immigration decreases the growth rate of prices for services and non-traded goods, whereas it tends to increase the prices of tradeable goods.

We introduce a measure of CPI prices as an unrestricted variable in our system and

we find no effect on the impact of the shock (cf. Figure 10). Nevertheless, CPI prices tend to increase in the medium run. Notably, this effect seems to be driven by a depreciation of the exchange rate, whereas a measure of domestic prices reacts substantially less to an immigration shock. While these effects are relatively small, in keeping with Frattini (2008), we uncover a new channel (the exchange rate channel) that, as far as we know, has not been discussed in the previous literature. Immigration shocks are important drivers of CPI prices in the medium run, whereas the sum of three labor market shocks captures a dominant share of fluctuations in the exchange rate. The effect on the exchange rate is quantitatively important as immigration shocks explain around 35% of exchange rate fluctuations at long horizons. In light of these results, investigating the link between labor supply and the exchange rate in theoretical models seems to be an interesting avenue for future research.

Immigration and productivity. The impact of immigration on productivity has been discussed in Peri (2012), who finds a strong positive association between immigration and total factor productivity (TFP) in US data. The main channel responsible for this result is task specialization. Peri and Sparber (2009) show that in states with large inflows of immigrants, natives with lower education tend to specialize in communication-intensive tasks, leaving more manual-intensive task to immigrants. The rebalancing produces task specialization based on comparative advantages and results in efficiency gains.

In our last experiment, we introduce labor productivity, measured as output per hour, as an unrestricted variable in our VAR (cf. Figure 10). We find that immigration shocks lower productivity in the medium run, thus confirming one of the conjectures proposed in the previous section to explain the short-lived effects of immigration on GDP. Notably, positive domestic labor supply shocks (associated with a decline in immigration) lead to a large positive effect on productivity. Therefore, both the exogenous and the endogenous component of immigration induce a decline in productivity. In fact, the variance decomposition suggests that the indirect effect (associated with the endogenous component) may be quantitatively more important to explain the possible negative effects of immigration on productivity.

A negative conditional correlation between immigration and productivity is not surprising since the two series are negatively correlated over the sample period. However, this result seems in contrast with the evidence for the US proposed by Peri (2012). To further investigate this issue, we now try to disentangle the different components of labor productivity. As shown under general assumptions by Bosler, Daly, Fernald and Hobijn (2016), labor productivity can be decomposed into TFP, capital intensity and labor quality. We use data on a measure of TFP (that however does not disentangle labor quality) and on capital intensity to isolate the effects of immigration shocks on the different components of labor productivity. In a first experiment, we include our measure of TFP as an unrestricted variable in the VAR. We see from Figure 10 that a positive immigration shock has a significant positive effect on TFP. In contrast, when we include capital intensity, we find a strong negative effect and immigration shocks are the dominant drivers of capital intensity. These more granular results are now consistent with Peri (2012) who also find a positive effect on TFP, possibly driven by task specialization, and a negative (although not statistically significant) effect on capital intensity. The dominant effect of immigration shocks on capital intensity in Norway may capture the fact that immigration shocks induce the adoption of less capital intensive and more unskilled efficient technologies. In keeping with this view, Lewis (2011) finds that US manufacturing plants located in areas that experienced faster growth in immigration adopted significantly less machinery per unit of output.

5 Conclusion

The economic impact of immigration is usually investigated in studies using detailed disaggregate data. This paper is one of the first attempts to include net immigration into the set of standard macroeconomic variables in a VAR model identified with a minimum set of sign restrictions. Our goal is to disentangle the drivers of immigration and the impact of immigration shocks on several variables that have been studied in the microeconomic literature. While a disaggregate approach can be more informative and detailed in several dimensions, an aggregate approach is needed to study business cycle fluctuations and

possibly also to discuss some implications for macroeconomic policies.

We do not find any support for some of the arguments recently used against immigration in terms of native employment displacement effects and burden on public finances. On the contrary we find that an exogenous positive immigration shock in Norway lowers unemployment (even among native workers) and has a small positive effect on public finances in the short run. Moreover, an exogenous increase in immigration has no impact on house prices and household credit growth, a small positive effect on prices in the medium run and a negative effect on productivity. While the fears for employment and the balance of public finances seem misplaced, the negative impact on labor productivity may be worrisome for long-term growth.

We conclude by briefly discussing the implications of our analysis for financial stability and monetary policy. On the one hand, as already mentioned, the exogenous component of immigration does not seem to pose clear challenges to financial stability, while the endogenous component may even have a stabilizing effect. On the other hand, our VAR framework is not equipped to discuss normative implications for monetary policy. Nevertheless, our analysis may give some indication of the effects of immigration on real economic activity and inflation, two key variables for monetary policy. In principle, the positive impact of immigration on the labor force may lead us to the conjecture that immigration has substantial effects on potential output. In practice, however, our analysis seems to downplay those effects. In fact, the negative effect on productivity limits the effects of the exogenous component of immigration on potential output, while the endogenous component of immigration reduces the effects of domestic labor supply shocks on potential output. The effects are larger if we consider the unemployment rate as a better indicator of real economic activity. As long as the natural rate of unemployment is relatively stable in response to exogenous variations in immigration, the fall in unemployment may indicate higher capacity utilization. The combination of a medium-run increase in inflation with higher capacity utilization suggests an expansionary effect of positive immigration shocks on key target variables for monetary policy.

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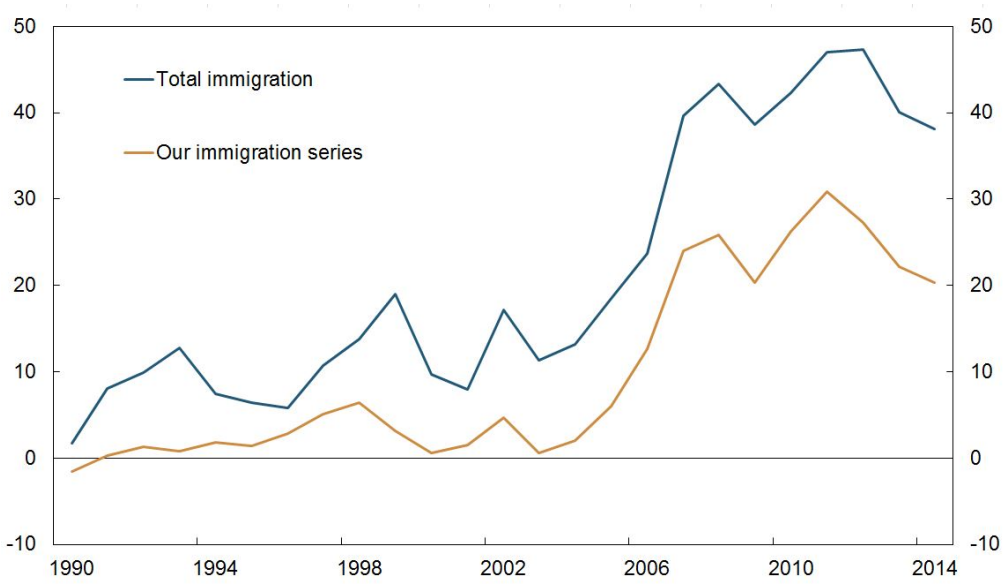

Figure 1: Net immigration to Norway in thousand people. Our immigration series include EU/EFTA countries, North America, Australia, New Zealand and Eastern Europe. Source: Statistics Norway

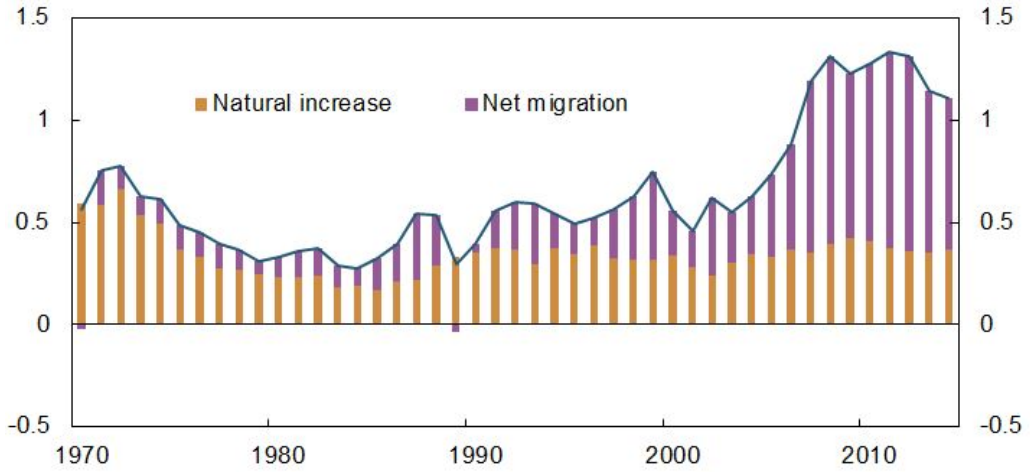

Figure 2: Annual change in population Norway. Percent. Source: Statistics Norway

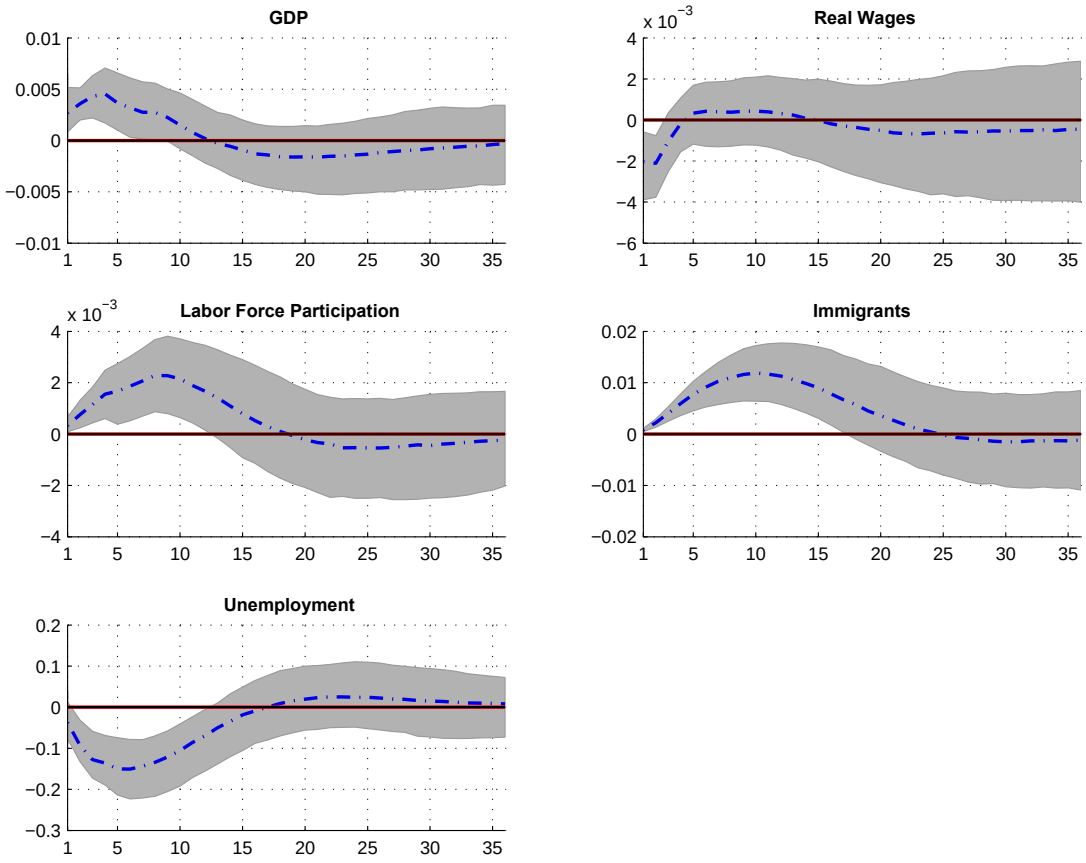

Figure 3: Impulse responses to an one-standard-deviation immigration shock in the baseline model. The dashed-dotted line represent the posterior median at each horizon and the shaded area indicates the 68th posterior probability region of the estimated impulse responses

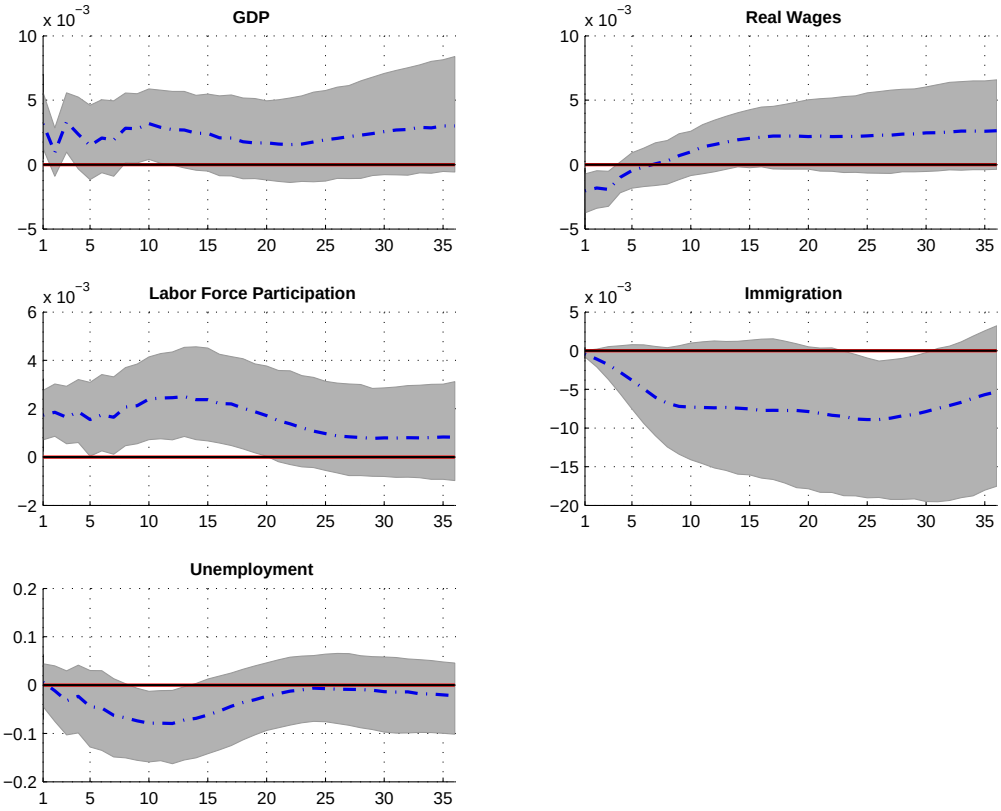

Figure 4: Impulse responses to an one-standard-deviation domestic labor supply shock in the baseline model. The dashed-dotted line represent the posterior median at each horizon and the shaded area indicates the 68th posterior probability region of the estimated impulse responses

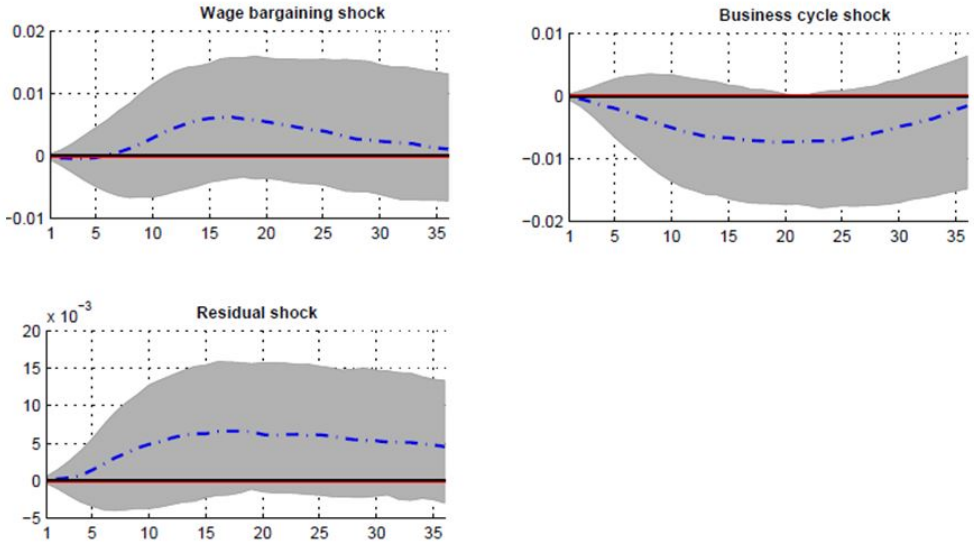

Figure 5: Impulse responses of immigration to a one-standard-deviation wage bargaining, business cycle and residual shock in the baseline model. The dashed-dotted line represent the posterior median at each horizon and the shaded area indicates the 68th posterior probability region of the estimated impulse responses

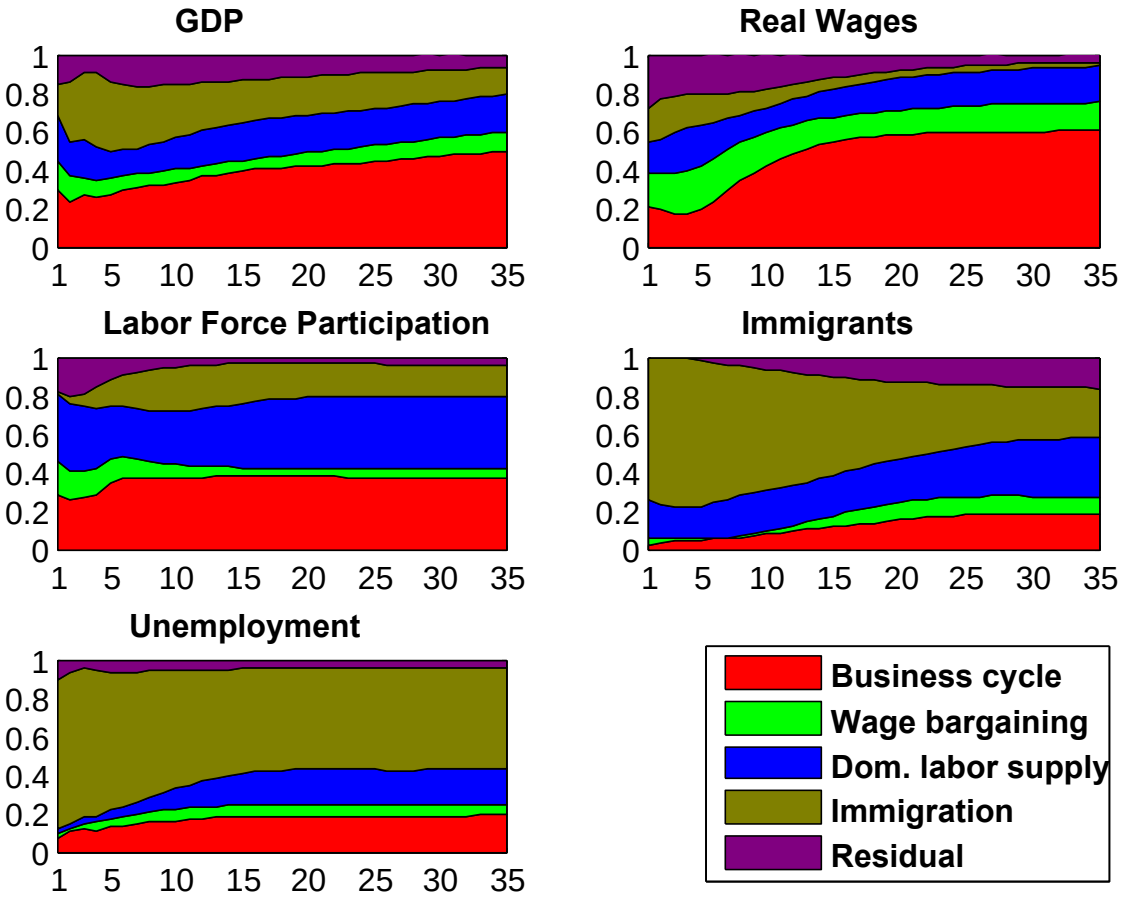

Figure 6: Median forecast error variance decomposition at each horizon in the baseline model

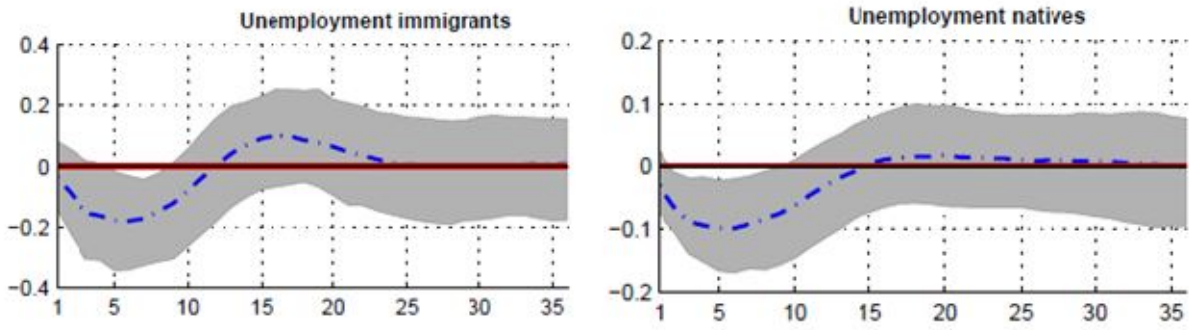

Figure 7: Impulse responses of different unemployment measures to a one-standard-deviation immigration shock where total unemployment in the baseline model is replaced by unemployment among natives and immigrants respectively. The dashed-dotted line represent the posterior median at each horizon and the shaded area indicates the 68th posterior probability region of the estimated impulse responses

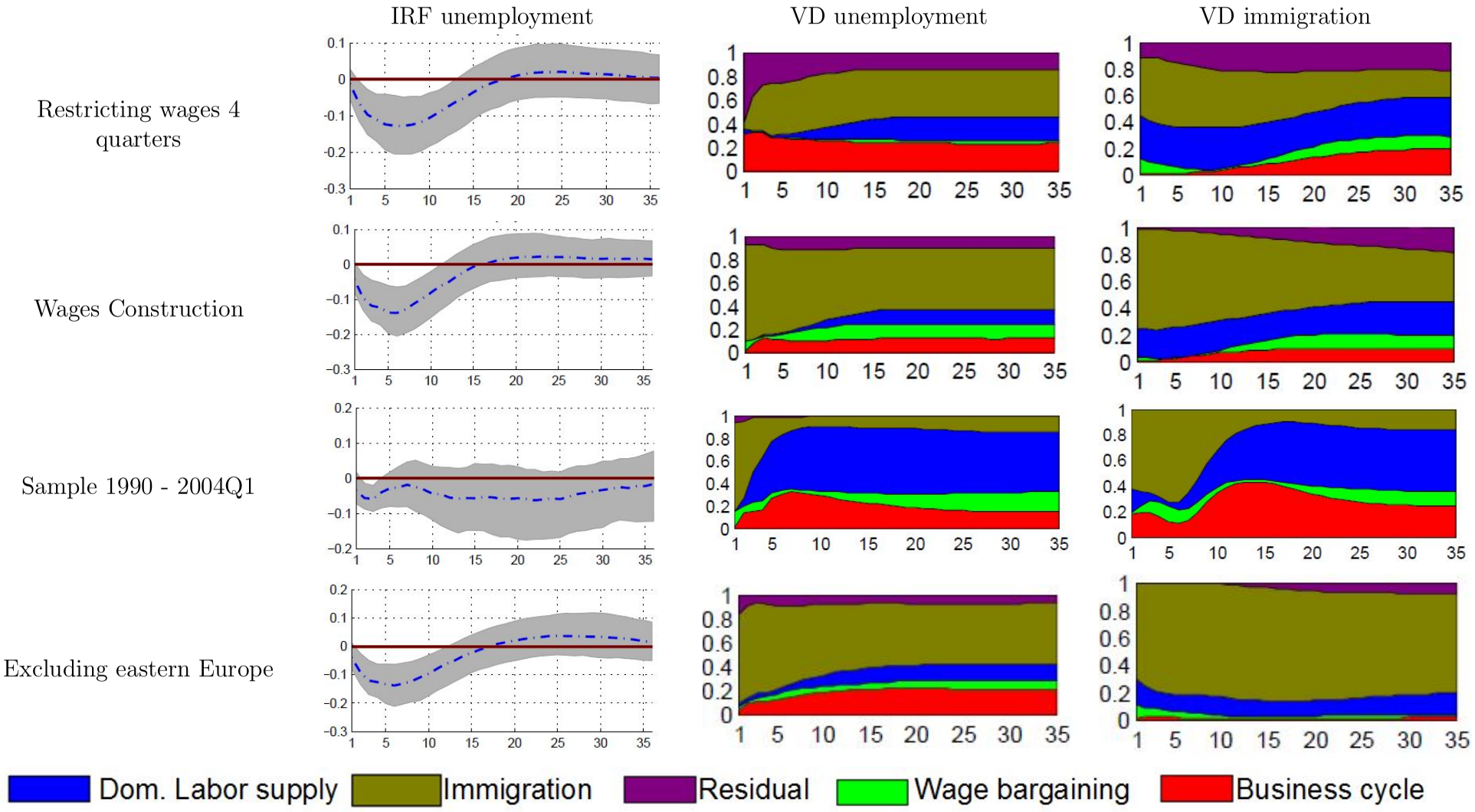

Figure 8: Robustness checks for the impulse response of unemployment to a immigration shock and for the variance decomposition of unemployment and immigration

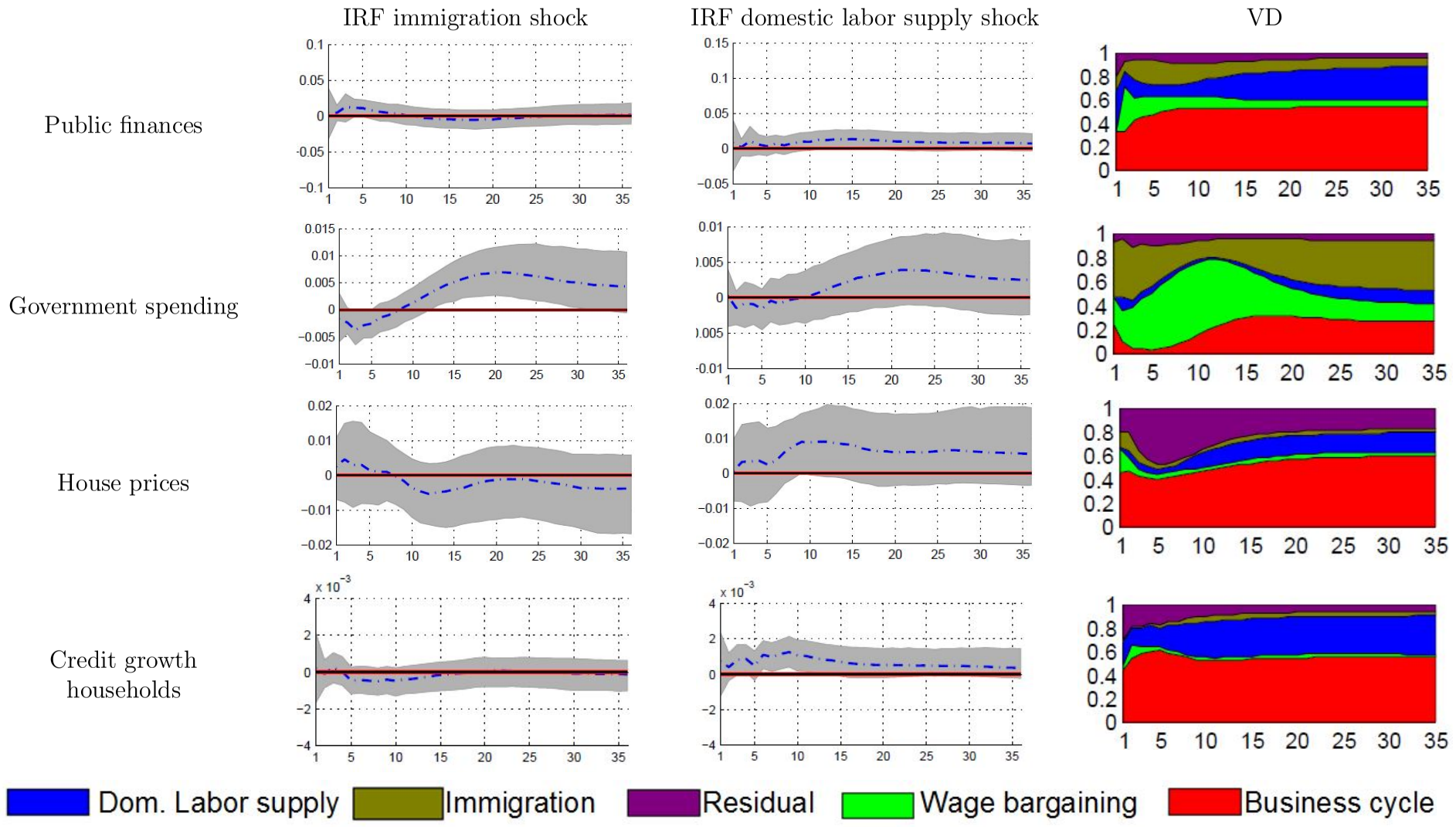

Figure 9: Selected impulse responses and variance decomposition for some variables of interest

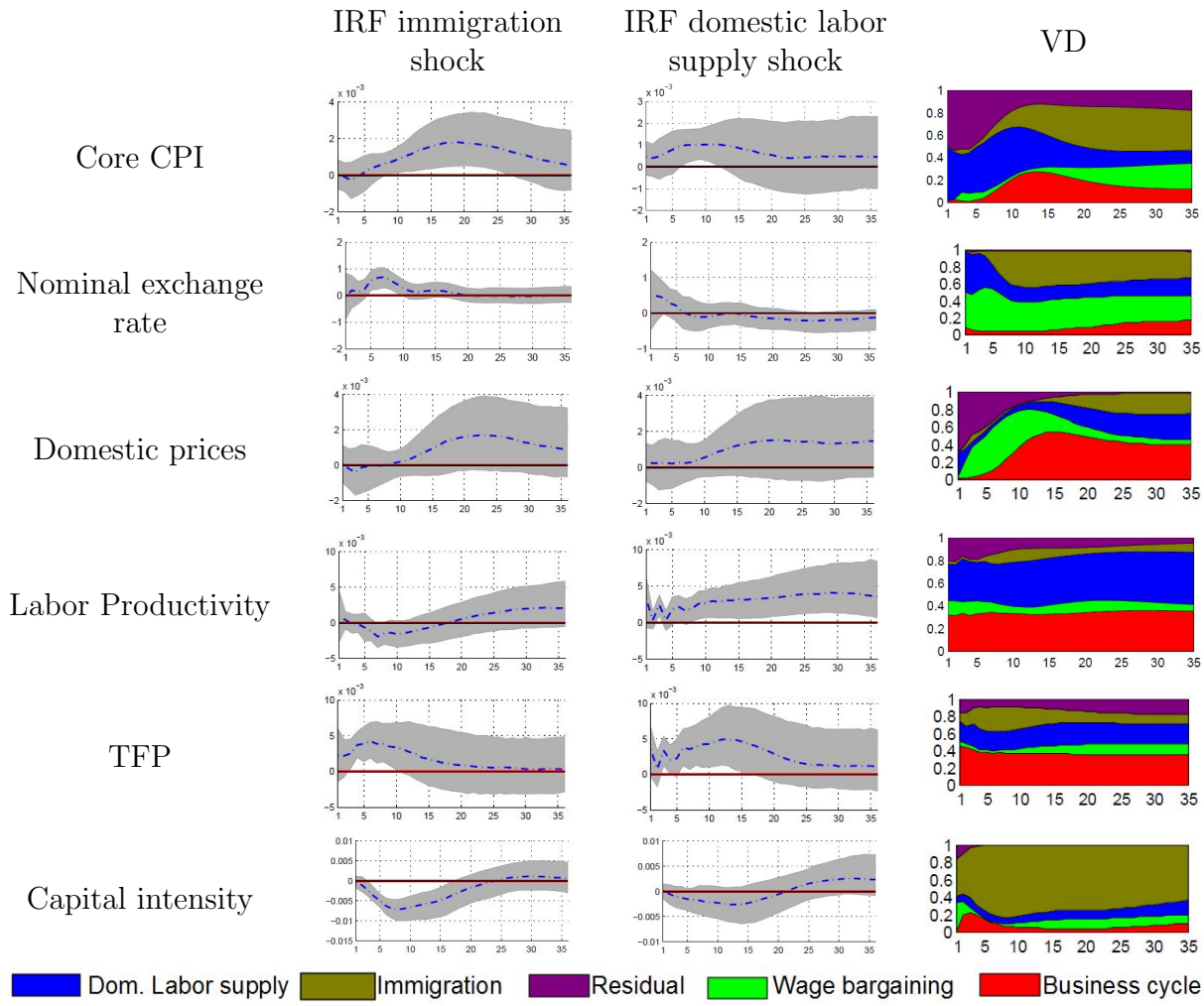

Figure 10: Selected impulse responses and variance decomposition for some variables of interest

A Appendix

A.1 Bayesian Estimation of the VAR

We illustrate in this Appendix the econometric procedure we use for the estimation of the different VAR models presented in the paper.

Estimation procedure

The VAR model described in (1) can be rewritten in a compact way as:

$$\mathbf{Y} = \mathbf{XB} + \mathbf{U}, \tag{2}$$

where $\mathbf{Y} = [y_1 \ \dots \ y_T]'$, $\mathbf{B} = [C_B \ B_1 \ \dots \ B_p]'$, $\mathbf{U} = [u_1 ... u_T]'$, and

$$\mathbf{X} = \begin{bmatrix} 1 & y_0' & \dots & y_{-p}' \\ \vdots & \vdots & \vdots & \vdots \\ 1 & y_{T-1}' & \dots & y_{T-p}' \end{bmatrix}.$$

Finally, for convenience, we rewrite (2) into its vectorized form:

$$\mathbf{y} = (I_n \otimes \mathbf{X})\beta + \mathbf{u}, \tag{3}$$

where $\mathbf{y} = vec(\mathbf{Y})$, $\beta = vec(\mathbf{B})$, $\mathbf{u} = vec(\mathbf{U})$, and with $vec()$ denoting columnwise vectorization. The error term $\mathbf{u}$ follows a normal distribution with a zero mean and variance-covariance matrix $\Sigma \otimes I_T$.

The likelihood function in $\mathbf{B}$ and Σ is defined as:

$$L(B, \Sigma) \propto |\Sigma|^{-\frac{T}{2}} \exp\left\{-\frac{1}{2}(\beta - \hat{\beta})'^{-1} \otimes \mathbf{X}'\mathbf{X})(\beta - \hat{\beta})\right\} \exp\left\{-\frac{1}{2} tr(\Sigma^{-1} S)\right\},$$

where $S = ((\mathbf{Y} - \mathbf{X}\hat{\mathbf{B}})'(\mathbf{Y} - \mathbf{X}\hat{\mathbf{B}}))$ and $\hat{\beta} = vec(\hat{\mathbf{B}})$ with $\hat{\mathbf{B}} = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{Y}$. We specify diffuse priors so that the information in the likelihood is dominant and these priors lead to a Normal-Wishart posterior. In more detail, we a diffuse prior for β and Σ that is

proportional to $|\Sigma|^{-(n+1)/2}$. The posterior becomes:

$$p(B,\Sigma|y) \propto |\Sigma|^{-\frac{T+n+1}{2}} \exp\left\{-\frac{1}{2}(\beta-\hat{\beta})'^{-1} \otimes \mathbf{X}'\mathbf{X}](\beta-\hat{\beta})\right\} \exp\left\{-\frac{1}{2}tr(\Sigma^{-1}S)\right\}, \quad (4)$$

where y denotes all available data.

The posterior in (4) is the product of a normal distribution for β conditional on Σ and an inverted Wishart distribution for Σ (see, e.g. Kadiyala and Karlsson, 1997 for the proof). We then draw β conditional on Σ from

$$\beta|\Sigma, y \sim N(\hat{\beta}, \Sigma \otimes (\mathbf{X}'\mathbf{X})^{-1})$$

and Σ from

$$\Sigma|y \sim IW(S, \nu),$$

where $\nu = (T-n) * (p-1)$ and N representing the normal distribution and IW the inverted Wishart distribution.

Identification procedure

In order to map the economically meaningful structural shocks from the reduced form estimated shocks, we need to impose restrictions on the variance covariance matrix we estimated.

In detail, the prediction error u_t can be written as a linear combination of structural innovations ϵ_t

$$u_t = A\epsilon_t$$

with $\epsilon_t \sim N(0, I_N)$, where I_N is an $(N \times N)$ identity matrix and where A is a non-singular parameter matrix. The variance-covariance matrix has thus the following structure $\Sigma = AA'$. Our goal is to identify A from the symmetric matrix Σ, and to do that we need to impose restrictions.

To obtain identification via sign restrictions, we follow the procedure described in Rubio-Ramirez, Waggoner and Zha (2010). The algorithm has the following steps. First, we compute A as the Cholesky decomposition of our estimated variance covariance ma-

trix. We then compute rotations of this matrix, computing first a matrix Q with a QR decomposition of $X = QR$, where X is drawn from $X \sim N(0, I_N)$. Then, we generate candidate impulse responses from AQ and B_i for $i = 1, ..., P$ and check if the generated impulse responses satisfy the sign restrictions. If the sign restrictions are satisfied, we store our impulse response, if not we draw a new X. We iterate over the same procedure again until we obtain 1000 impulse responses which satisfy our sign restrictions.

A.2 Data sources

This subsection lists the sources of the data series used in this paper. When the original data series is at a monthly frequency, we take quarterly averages of monthly data. All data series enter the VARs in logs except for unemployment which enters in percent of the workforce.

Immigration rate: Stock of immigrants in the country in percent of population aged 15-74. We include immigrants from EU/EFTA countries, North America, Australia, New Zealand and Eastern Europe. Quarterly gross immigration is collected from Statistics Norway. Net immigration is calculated using interpolated yearly data for emigration. The stock of immigrants is accumulated net immigration. *Sources: Statistics Norway and Norges Bank*

Real wage: Seasonally adjusted wage costs per hour deflated with the price level (CPI-ATE). *Sources: Statistics Norway and Norges Bank*

Participation rate: Seasonally adjusted workforce aged 15-74 in percent of population aged 15-74 from the Labor force survey. *Sources: Statistics Norway and Norges Bank*

Unemployment rate: Seasonally adjusted registered unemployment rate from the Norwegian Labour and Welfare Administration (NAV). *Sources: Statistics Norway and NAV*

GDP mainland Norway: Seasonally adjusted GDP mainland Norway (volumes) from national accounts. *Source: Statistics Norway*

Prices: Seasonally adjusted consumer price index adjusted for tax changes and excluding energy products (CPI-ATE). *Sources: Statistics Norway and Norges Bank*

Domestic Prices: Seasonally adjusted consumer price index domestic sources adjusted for tax changes and excluding energy products. *Sources: Statistics Norway and Norges Bank*

Exchange rate: Trade-weighted nominal exchange rate index (I-44) for 44 trading partners. *Sources: Thomson Reuters, Ecowin and Norges Bank*

Hours worked: Total hours worked in mainland Norway from national accounts adjusted for population growth. *Source: Statistics Norway*

Population: Population from 15 to 74. *Source: Statistics Norway*

House prices: Seasonally adjusted nominal house prices deflated by the CPI-ATE. *Sources: Statistics Norway, Eiendomsmeglerforetakenes forening (EFF), Finn.no, Eiendomsverdi and Norges Bank*

Household credit: Seasonally adjusted C2 for households chained and break-adjusted deflated by the CPI-ATE and adjusted for population growth. Included in first differences. *Sources: Statistics Norway and Norges Bank*

Labor Productivity: Seasonally adjusted GDP mainland Norway (volumes) divided by hours worked. *Source: Statistics Norway*

TFP and capital intensity: Labor productivity decomposed into total factor productivity and capital intensity using a Cobb-Douglas production function. Data on capital, GDP, hours and labor income share for mainland Norway are used in the calculation. *Source: Statistics Norway and Norges Bank*

Government spending: Total expenditure from the quarterly central government fiscal account. Seasonally adjusted. *Sources: Statistics Norway and Norges Bank*

Public finances: Difference between tax income (excluding oil taxes) and government spending from the quarterly central government fiscal account. Seasonally adjusted. *Sources: Statistics Norway and Norges Bank*