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On the Macroeconomic Effects of Immigration: A VAR Analysis for the US

Sebastian Weiske*)
(German Council of Economic Experts)

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*) Staff of the German Council of Economic Experts, E-Mail: sebastian.weiske@svr-wirtschaft.de.

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On the Macroeconomic Effects of Immigration: A VAR Analysis for the US*

Sebastian Weiske†

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Abstract

This paper estimates the quarterly flow of migrants to the US working age population using data based on the Current Population Survey (CPS). The dynamic responses to immigration shocks are estimated in a vector autoregression. Immigration shocks, as well as technology shocks are identified through long-run restrictions. The responses to immigration shocks are consistent with standard growth theory. Investment increases, while real wages fall in the short run. Overall, immigration has been of little importance for US business cycles, while investment-specific technology shocks have been a major driver of immigration during the 1990s and 2000s.

Keywords: Immigration, business cycles, vector autoregressions, long-run restrictions.

JEL Codes: E32, F22, J11, J61.

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†Staff of the German Council of Economic Experts, E-mail: sebastian.weiske@svr-wirtschaft.de.

1 Introduction

Few issues are as controversial as immigration. Many of the arguments concern its impact on the economy. Some see immigrants as an enrichment promoting growth and investment. Other see immigrants rather as a threat to native workers, lowering wages and increasing the competition for jobs. I address the following questions in this paper. How important has immigration been for the US economy in recent decades? What is the effect of immigration on different macroeconomic variables, such as wages, investment, or consumption?

Immigration is a nationwide political issue and is regulated mainly at the federal level. It is therefore important to analyze its implications from a macroeconomic, or aggregate, perspective. While many papers have analyzed the effects of immigration on different markets, such as labor markets for example, there has been little empirical research at the macroeconomic level. The main reason is the lack of adequate data. This paper helps to fill this gap by estimating the macroeconomic effects of immigration to the United States using established time series techniques. I proceed in two steps.

First, I construct an estimate of the *quarterly* net flow of migrants to the US working age population for the period 1957Q1-2016Q2, using data from the Current Population Survey (CPS). There is no direct quarterly measure of immigration to the US working age population. In order to obtain an estimate for the number of immigrants, I follow Kiguchi and Mountford (2013) who estimate the *annual* flow of immigrants to the United States.[1] Net migration to the United States is calculated as the change in the civilian noninstitutuional population 16 years and older that is not due to variations in fertility, mortality, or changes in the US military personnel. This decomposition provides some stylized facts about immigration to the United States over the last five decades. First, the annual number of migrants entering the US working age population has doubled since the 1960s. During the last two decades, the civilian population increased on average by somewhat less than one million per year due to immigration. Second, migration from Mexico accounted for the major part of total net migration to the United States during the 1990s and 2000s, whereas refugees have accounted for only less than 10% of total migration during the last 35 years. Third, the number of migrants relative to the US civilian population has fluctuated over time. Immigration rates were relatively high during the periods 1970Q4-1980Q3 and 1998Q4-2007Q3.

In the second step, I estimate the responses of different macroeconomic variables to

[1] Henceforth I will use the terms net migration and immigration interchangeably, although it is the net flow of migrants, i.e. immigrants minus emigrants, that is estimated in this paper.

immigration shocks using a vector autoregression (VAR). A major problem with estimating the impact of immigrants on the economy is that immigration is endogenous, meaning that the decision to migrate to another country depends not only on the conditions in the home country, but also on the conditions in the destination country. In other words, there are push, as well as pull factors of migration. This creates obvious difficulties in obtaining an unbiased estimate of its economic effects in the destination country. In this paper, immigration shocks are identified through long-run restrictions. In total, three different shocks are identified: *investment-specific technology* shocks (henceforth investment technology shocks), *investment-neutral technology* shocks (henceforth neutral technology shocks), and *immigration* shocks. Previous empirical studies, e.g. Fisher (2006), have found that the two different technology shocks account for most of the macroeconomic variation at business cycle frequencies. I follow the literature in assuming that (i) innovations to technology - both investment and neutral - are the only shocks that affect labor productivity in the long run, and (ii) that investment technology shocks are the only shocks that affect the real price of investment in the long run. In addition, I assume that only technology and immigration shocks have a permanent effect on migration. This means that other transitory business cycle shocks, e.g. demand shocks, that leave labor productivity unaffected in the long run also leave immigration unaffected in the long run. The focus of this paper is thus on immigration shocks that increase the US civilian population permanently. It ignore transitory fluctuations in the number of the US foreign-born population.

The main findings are as follows. First, immigration shocks are of minor importance for the US economy. They account for less than 10% of the business cycle variation in output, labor, wages, consumption, and investment. Second, investment technology shocks explain about 20-25% of the long-run variation in immigration. In particular, the accelerating decline in investment prices during the 1990s coincided with a substantial increase in immigration to the United States. Third, in response to a positive immigration shock, real wages fall and investment per capita increases. The fall in wages is significant for about 2 years after the shock, whereas the increase in investment is significant for a period of 2-5 years after the shock. Output, hours, and consumption (all per capita) show little change after an immigration shock. The findings are robust to (i) the inclusion of CPS data revisions in the estimated series for migration, and (ii) the specification of hours in the VAR.[2]

[2]The CPS is subject to frequent changes in its population controls, which incorporate new vital and migration statistics. This leads to large changes in the size of the civilian population over time that may be unrelated to actual changes in the civilian population in the respective quarter. Some of the revisions can be directly and solely linked to new information on the foreign-born population. Other revisions, in

Related Literature There are only few papers that investigate the macroeconomic effects of immigration using time series techniques.[3]

The paper that is closest to this is Kiguchi and Mountford (2013). Following them, I include an estimate of migration to the US civilian population in a vector autoregression model of the US economy. One difference to Kiguchi and Mountford (2013) concerns to the identification strategy. Kiguchi and Mountford (2013) use sign restrictions to identify immigration shocks. A positive response of the immigration series is the only restriction that they impose on the responses following an immigration shock. Therefore, responses to immigration shocks may have the same sign as other business cycle shocks (Furlanetto and Robstad, 2016, p. 5). Here, I use long-run restrictions in order to identify immigration shocks, building on a long tradition in the literature (Blanchard and Quah, 1989; Galí, 1999; Christiano et al., 2003; Galí and Rabanal, 2004; Francis and Ramey, 2005; Fisher, 2006). According to my results, immigration lowers real wages and increases investment in the short run, whereas Kiguchi and Mountford (2013) find no such effect. Further differences concern the estimation of net migration to the civilian population. I estimate the quarterly flow of migrants, whereas Kiguchi and Mountford (2013) estimate the annual flow. Furthermore, I account for revisions of the CPS and correct the migration series for flows between the civilian population and the US military.

Furlanetto and Robstad (2016) estimate the effects of immigration using Norwegian data from 1990Q1 to 2014Q2. They identify immigration shocks by imposing sign restrictions on the VAR responses to immigration shocks. In particular, an immigration shock increases total GDP, lowers real wages, increases the participation rate, and increases the ratio of immigrants to participants. One drawback of identifying shocks through sign restrictions is that one cannot say much about the responses of the restricted variables apart from their magnitude and shape. Another challenge is to properly separate immigration shocks from other shocks. Furlanetto and Robstad (2016) identify four shocks: business cycle shocks, wage bargaining shocks, domestic labor supply shocks, and immigration shocks. One of their main results is that positive immigration shocks lower unemployment and that immigration to Norway has been the main driver (>50%) of unemployment both in the short and in the long run.

Smith and Thoenissen (2018) analyze the macroeconomic effects of migration to New

particular following the decennial Census, most likely also include revised estimates of mortality in the United States as well as other statistical adjustments.

[3] Ortega and Peri (2009) collect annual data for immigration between OECD countries and estimate the aggregate effects of immigration by specifying a pseudo-gravity equation for international migration. They find that immigration shocks lead to a proportional increase in total employment, output, and capital with no evidence for a crowding out of the native population.

Zealand. Using an estimated small-open economy model and a structural vector autoregression, they find that migration shocks account for a substantial portion of the variability of per-capita GDP. They also find that a migration shock may have an expansionary impact on GDP per person, depending on whether immigrants have a higher level of human capital than natives.

This paper also contributes to the literature estimating the wage effects of immigrants to the United States (Borjas, 2003; Card, 2005, 2009; Ottaviano and Peri, 2008, 2012). [4] These authors have emphasized three conceptual challenges that researchers face when estimating the labor market impact of immigration. First, immigration reacts to economic conditions in the destination country. Second, natives may respond to immigration by moving to other regions or sectors that are less affected by migration. Third, an estimate of the degree and speed of capital adjustment following an immigration shock is needed in order to assess its short-run aggregate effects on wages. This paper acknowledges these concerns by looking at aggregate data for the United States and by estimating the macroeconomic effects of immigration in a structural VAR. I find that aggregate wages fall on impact by around 0.2 percent after a one standard deviation immigration shock. At the same time, aggregate investment increases such that the negative effect on wages disappears after about 2 years.

Several papers have analyzed the effects of immigration using general equilibrium models. Canova and Ravn (2000) model the German reunification as a large inflow of low-skilled workers. Storesletten (2000) calculates the fiscal impact of immigrants in a large-scale overlapping generations model. Hazari and Sgro (2003) and Moy and Yip (2006) analyze the long-run welfare consequences of illegal immigration for natives within a neoclassical growth model. Ben-Gad (2004, 2008) analyzes the impact of immigration on capital accumulation and factor prices in a model of overlapping dynasties. Finally, Mandelman and Zlate (2012) build a two-country model featuring unskilled labor migration and remittances. They estimate the model using data for the United States and Mexico. The empirical results found my paper are broadly consistent with those predictions based on neoclassical growth theory.

The rest of the paper is organized as follows. Section 2 provides details on the immigration series. Section 3 presents the VAR evidence. Section 4 concludes.

[4] Manacorda et al. (2012) and Dustmann et al. (2013) obtain estimates for the United Kingdom.

2 Immigration to the United States

This section describes how the time series for immigration to the United States is constructed. Following Kiguchi and Mountford (2013), I decompose the quarterly changes in the US working age population as follows

$$\begin{aligned} \Delta CNP16OV_t &= \underbrace{(b_{t-16y,t} \times Births_{t-16y} - Deaths_t)}_{\Delta N_{1,t}} - \Delta Military_t \\ &\quad + Revisions_t + \Delta N_{2,t}, \end{aligned} \tag{1}$$

where $CNP16OV_t$ is the civilian noninstitutional population 16 years and older, obtained from the Current Population Survey (CPS), $b_{t-16y,t}$ is the survival probability of a newborn to age 16, $Births_{t-16y}$ is the number of live births 16 years ago, $Deaths_t$ is the number of deaths 16 years and older, $\Delta N_{1,t}$ is the natural population change, $\Delta Military_t$ is the change in worldwide US military personnel, $Revisions_t$ are CPS data revisions unrelated to migration, and $\Delta N_{2,t}$ is the *residual* time series that represents the estimated net flow of migrants to the US civilian population.[5] $\Delta N_{2,t}$ accounts for the change in the civilian noninstitutional population that is not due to past changes in fertility ($b_{t-16y,t} \times Births_{t-16y}$), current deaths ($-Deaths_t$), or net flows to the US military ($-\Delta Military_t$). Table 3 in Appendix A summarizes the population data that is used for constructing the quarterly immigration series $\Delta N_{2,t}$.

As noted by Edge et al. (2016), the civilian noninstitutional population series from the CPS is calculated on a "best levels" basis, that is the time series is occasionally adjusted as new information about the population becomes available, while earlier data points remain unchanged. This generates sizable peaks in the population growth series that are generally unrelated to actual changes in the size of the civilian population in that period. Revisions are due to new information on the foreign-born population that has not been properly accounted for in the past. They also capture methodological changes

[5] The civilian noninstitutional population is defined as "persons 16 years of age or older residing in the 50 states and the District of Columbia, who are not inmates of institutions (e.g., penal and mental facilities, home for the ages), and who are not on active duty in the Armed Forces." (BLS website) The civilian noninstitutional population is the only aggregate population series available at a quarterly frequency for the United States. It is therefore used in basically all empirical studies involving per-capita aggregates, such as GDP per capita, for example.

in the CPS.[6] Table 4 in Appendix A contains details on the CPS data revisions.[7] Some of the revisions can be exclusively linked to immigration (marked in the last column of Table 4). They are included in $\Delta N_{2,t}$. Most of the other revisions, however, contain not only new information on previous migration to the United States, but also reflect other population control adjustments regarding birth and death statistics, for example. Without further information, it is not possible to properly extract the revisions due to immigration only. Take for example the revisions reflecting decennial US census data, which have all led to upward revisions of the civilian population, except for the 1960 census. These revisions could reflect unexpectedly high immigration numbers, but they could be also driven by the secular decline in mortality, which, once taken into account, led to upward revisions of the civilian population size.

Figure 7 in Appendix A shows the annual changes in the civilian population due to net migration (excl. all revisions), together with the CPS revisions that cannot be directly and exclusively linked to migration. Since 2005, the CPS data is revised at the beginning of each year. Figure 7 suggests that downward revisions were more likely to occur in years with falling migration numbers. In the baseline specification for the VAR all CPS revisions are included in $\Delta N_{2,t}$. But I also conduct a robustness check, in which only those CPS revisions that are exclusively due to new information on immigration are included in $\Delta N_{2,t}$.

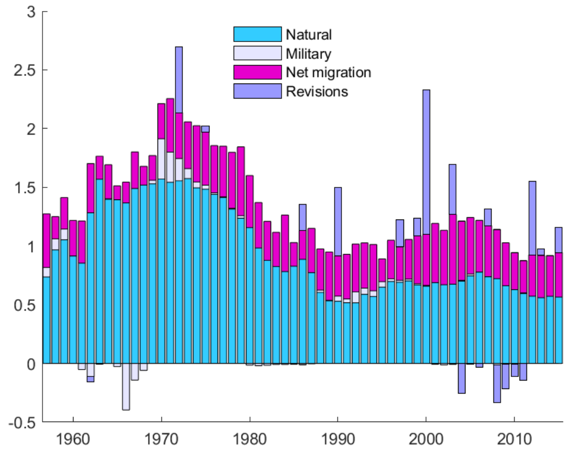
The population series that is used in the empirical analysis of the next section is then constructed as follows

$$N_{2,t} = CNP16OV_{1956Q4} + \sum_{t=1957Q1}^{2016Q2} \Delta N_{2,t}. \tag{2}$$

$N_{2,t}$ is an estimate of the US civilian noninstitutional population, controlling for (i) changes in demographics (births and deaths) and (ii) net flows to the US military. Figure 1 shows a decomposition of the annual civilian population growth rate into four components: the difference between births and deaths (the so called natural population

[6]The purpose of the CPS is to serve as "the primary source of labor force statistics for the population of the United States" (CPS website). In order to achieve this, the CPS is subject to regular data revisions ensuring that a representative sample of the civilian noninstitutional population is obtained. These revisions make the historical comparability of data on the civilian population difficult. This means that the date of arrival of an immigrant does not necessarily correspond to the date of his appearance in the CPS, as some immigrants are captured only gradually by the CPS. But eventually, migrants are included in the CPS through the revisions.

[7]Table 4 provides an overview of the CPS revisions. The checkmarks in the last two columns indicate whether revisions are included in $\Delta N_{2,t}$. In the baseline case all revisions, except for January 1960, are included in $\Delta N_{2,t}$. In the robustness checks, only revisions that are explicitly and exclusively linked to migration are included in $\Delta N_{2,t}$.



Annual. Percentage points. Sources: NCHS, BLS/CPS, Cociuba et al. (2012), and own calculations.

Figure 1: US Population Growth 1957-2015

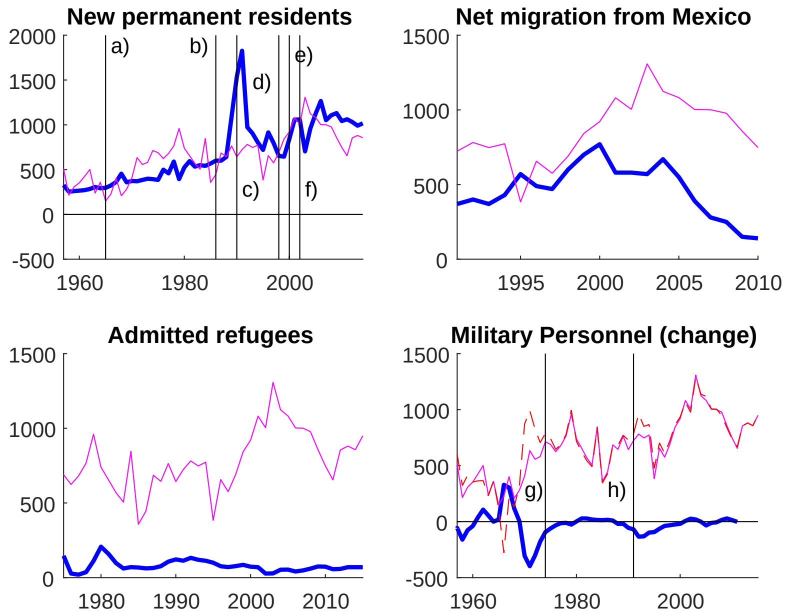
growth rate), net flows to the US military, the contribution of net migration, and CPS data revisions.[8]

Figure 2 presents the changes in the civilian noninstitutional population due to net migration (thin lines) together with (i) the number of persons obtaining permanent resident status (top, left), (ii) an estimate of annual net migration from Mexico (top, right), (iii) the number of admitted refugees to the United States (bottom, left), and (iv) the changes in US military personnel (bottom, right).[9]

As can be seen from the upper left panel, the two immigration series follow a very similar pattern reflecting, inter alia, several immigration reforms in the United States during the last decades. As pointed out by Kiguchi and Mountford (2013, p. 5), the two series do not necessarily coincide, "since one can attain new permanent resident status and not be part of the working population and vice versa." One of the most important legislative changes was the Immigration Reform and Control Act (IRCA) of 1986 that granted legal status to undocumented immigrants in the United States who had entered the country prior to 1982. Almost three million undocumented immigrants finally received legal status under the IRCA. This explains why the number of new permanent residents increased dramatically during the late 1980s. It also explains why the number of new permanent residents had been below the number of migrants to the civilian population before 1982.

[8]The growth rate of the civilian population is calculated as $\frac{CNP16OV_t}{CNP16OV_{t-1}} - 1$.

[9]In the net migration series shown here, data revisions are excluded to improve visibility. As mentioned earlier (see also Figure 1), data revisions generate sizable peaks in the civilian population growth series.



Thin solid lines: net migration to civilian population (excl. revisions). Top, left (thick solid line): number of persons obtaining permanent resident status. Top, right (thick solid line): estimate of annual immigrants from Mexico. Bottom, left (thick solid line): number of admitted refugees to the United States. Bottom, right (thick solid line): change in US military personnel. Bottom, right (dashed line): migration series uncorrected for $\Delta Military$. a): Immigration Act of 1965, b) Immigration Act of 1986, c): Immigration Act of 1990, d): American Competitiveness and Workforce Improvement Act, e): American Competitiveness in the 21st Century Act, f): Homeland Security Act, g): End of the Vietnam War, h): End of the Cold War. Numbers per year and in units of thousand. Sources: NCHS, BLS/CPS, DHS, DOS, Passel et al. (2012), Cociuba et al. (2012), and own calculations.

Figure 2: Immigration to the United States 1957-2015

The upper right panel highlights the contribution of Mexican migration to the United States for the total number of immigrants between 1990 and 2010. It also shows the sizable increase in net migration from Mexico during the 1990s and its subsequent decline. Refugees have played only a minor role for US immigration (lower left panel). They account for a tiny fraction of total migration to the US working age population. A significant number of refugees was admitted to the United States only in the early 1980s, and to a lesser extent, during the early 1990s. The number of refugees fell from more than 200,000 in 1980 to around 60,000 in 1986 and increased again to about 130,000 in 1991. Since the mid-1990s the annual number of refuges has remained below 100,000.

There were sizable flows between the civilian noninstitutional population and the active duty US military personnel during the Vietnam War (lower right panel of Figure 2). The size of the armed forces increased from 2.66 million in 1965 to 3.55 million in 1968, and then fell to 2.25 in 1973. Not accounting for these flows (dashed line) would lead to the erroneous conclusion that net migration was negative in the late 1960s, whereas in fact the civilian population was shrinking due to military recruitment during the Vietnam war. Despite the Gulf and the Iraq War, there have been no such abrupt changes in the number of military personnel later than 1973. Only after the end of the Cold War, the US military personnel was significantly reduced by about 0.6 million persons. This reduction happened rather gradually, though.

Is there statistical evidence for structural breaks in the number of migrants to the United States? A test for structural breaks following Bai and Perron (2003) suggests two break dates: 1970Q4 and 2000Q1. See Table 5 and Figure 8 in Appendix A. The left panel of Figure 8 suggests ever higher levels of immigration to the United States, with rates accelerating around 1970 and 2000. This, however, ignores that the total US population has doubled since the 1950s. It is therefore more reasonable to consider migration relative to the total civilian population. The right panel of Figure 8 shows the percentage change in the civilian population that is due to net migration. A test for structural changes detects four break dates: 1970Q4, 1980Q3, 1998Q4, 2007Q3. This suggests two periods of particularly high immigration rates: from 1970Q4 to 1980Q3 and from 1998Q4 to 2007Q3.

3 VAR Evidence: Technology and Immigration Shocks

The next section estimates the responses to immigration shocks. Before specifying the VAR, I first discuss the assumptions underlying the identification of immigration shocks.

Table 1: Long-Run Restrictions

Variable/Shock	Investment	Neutral	Immigration	Other
Investment Price	·	0	0	0
Productivity	·	·	0	0
Population	·	·	·	0
Other	·	·	·	·

Identification Immigration is endogenous, meaning that the decision to migrate depends on several factors that are not only related to economic conditions in the countries of origin, but also to economic conditions in the destination country. This complicates the identification of variations in immigration that are exogenous to the state of the US economy.

To separate immigration shocks from other macroeconomic shocks, several exclusion restrictions are required. In this paper, immigration shocks are disentangled from other shocks through long-run restrictions. Within the VAR I identify three different shocks: investment technology shocks, neutral technology shocks, and immigration shocks. Table 1 reports the long-run restrictions, which can be summarized as follows. First, only investment technology shocks affect the relative price of investment in the long run (Fisher, 2006). Second, only technology shocks - investment or neutral - affect labor productivity in the long run (Galí, 1999). Third, only technology and immigration shocks affect immigration in the long run. The first two restrictions are standard in the literature. They are consistent with macroeconomic theory. The third restriction implies that the decision to permanently settle in the United States is either affected by long-run economic conditions in the United States, which are reflected by changes in labor productivity, or by immigration shocks. This also means that transitory business cycle shocks that leave labor productivity unaffected in the long run have no long-run effect on immigration either. For example, a worker moving from Mexico to the United States in response to favorable short-run economic conditions is assumed to move back to Mexico once economic conditions in the United States worsen.

As noted by Uhlig (2004) or Francis and Ramey (2005), technology shocks that are identified using long-run restrictions may also capture other shocks, such as changes in capitalincome taxes. This affects of course the interpretation of the first two shocks, but not the interpretation of the identified immigration shocks. For this paper, it is not important to distinguish immigration shocks from technology shocks only, but to distinguish immigration shocks from any shock that potentially affects both labor productivity and immigration in the long run.

VAR The VAR(p) model is

$$y_t = c_t + \sum_{j=1}^{p} B_j y_{t-j} + u_t, \tag{3}$$

with $\mathbb{E}[u_t u_t'] = \Sigma$. Here, y_t is a $N \times 1$ vector of data. The vector c_t is a deterministically broken intercept term accounting for structural breaks in US time series. Structural VARs with technology shocks identified by long-run restrictions are very sensitive to the low-frequency correlation between productivity growth and hours worked. Allowing for trend breaks, the results are much less sensitive (Fernald, 2007; Canova et al., 2010). The break dates are 1973Q2, 1997Q2, and 2003Q4 (Fernald, 2014). B_j are coefficient matrices of size $N \times N$, and u_t is the one-step ahead prediction error with variance-covariance matrix Σ. The sample period is 1959Q1-2016Q2. The number of lags is four.

Let ε_t denote the structural, or fundamental shocks with $\mathbb{E}[\varepsilon_t \varepsilon_t'] = I$. Identification amounts to finding a matrix A such that $u_t = A\varepsilon_t$. $N(N+1)/2$ restrictions come from $AA' = \Sigma$. Hence, $N(N-1)/2$ restrictions are needed to achieve exact identification. In this paper, these restrictions come from imposing zero entries on the long-run impact matrix. The long-run structural impact matrix is approximated following Uhlig (2004) and Balleer (2012).[10] The VAR is estimated using Bayesian techniques. I employ a noninformative prior. The impulse responses are calculated using 1,000 draws from the posterior distribution (Sims and Zha, 1999). This procedure is feasible given that the model is exactly identified.

The variables included in the VAR are

$$y_t = \begin{bmatrix} \Delta \ln(P_t^I / P_t^Y) \\ \Delta \ln(Y_t / Hours_t) \\ \Delta \ln(N_{2,t}) \\ \ln(Hours_t / CNP16OV_t) \\ \ln(Y_t / Hours_t) - \ln(W_t / P_t) \\ \ln(C_t / Y_t) \\ \ln(I_t / Y_t) \end{bmatrix} \sim I(0), \tag{4}$$

where P_t^I / P_t^Y is the relative price of investment, $Y_t / Hours_t$ is labor productivity mea-

[10] Let $C_\infty = \sum_{j=0}^{\infty} \Phi_j A$ denote the long-run impact matrix, where Φ_j are the impulse-response coefficients. Calculate the forecast-error variance matrix $\Gamma \equiv MSE(k) = C_k \Sigma C_k'$, with $C_k \equiv \sum_{j=0}^{k} \Phi_i$ and $k = 80$ (i.e. 20 years). Finally, the matrix C that approximates C_∞ is obtained through a Cholesky decomposition of Γ, i.e. $\Gamma = CC'$ with $C = C_k A$ lower-triangular and where the structural impact matrix is given by $A = C_k^{-1} C$.

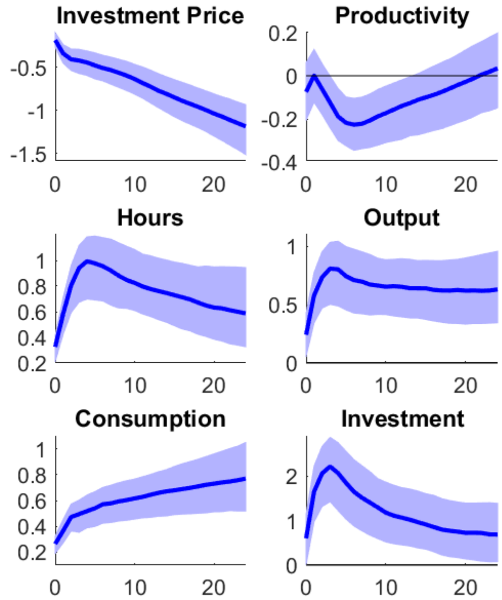
sured by output per hour, $N_{2,t}$ is the civilian population series as constructed in the previous section, $Hours_t/CNP16OV_t$ are hours per person, W_t/P_t is the real wage, C_t/Y_t is the consumption share, and I_t/Y_t is the investment share. Cointegration relationships between labor productivity and real wages, between consumption and output, and between investment and output, are imposed based on economic theory. Except for the population series $N_{2,t}$, all variables enter the VAR in the same way as in Christiano et al. (2003) or Altig et al. (2011).[11] For a detailed description of the data see Table 6 in Appendix A. As discussed in section 2, $N_{2,t}$ includes all CPS revisions in the baseline specification.

Impulse responses Figures 3-5 show the responses to the three identified shocks. The numbers give the percentage point (henceforth pp) change of the different variables to a one standard deviation shock. Hours, output, consumption, and investment are all expressed in per-capita terms. Productivity is output per hour worked.

Figure 3 shows the responses to an investment technology shock. Investment technology shocks lead to an increase in output, hours, consumption, and investment. Real wages barely react to investment technology shocks and labor productivity temporarily falls - see also Altig et al. (2011, Fig. 3). Interestingly, immigration responds positively to investment technology shocks. A one standard deviation investment technology shock leads to an increase in the civilian population of 0.1 pp after 6 years. Figure 4 shows the responses to a neutral technology shock. Neutral technology shocks lead to a persistent rise in output, real wages, consumption, and investment. Hours increase only after about two years. Other than investment technology shocks, neutral technology shocks have almost no effect on immigration.

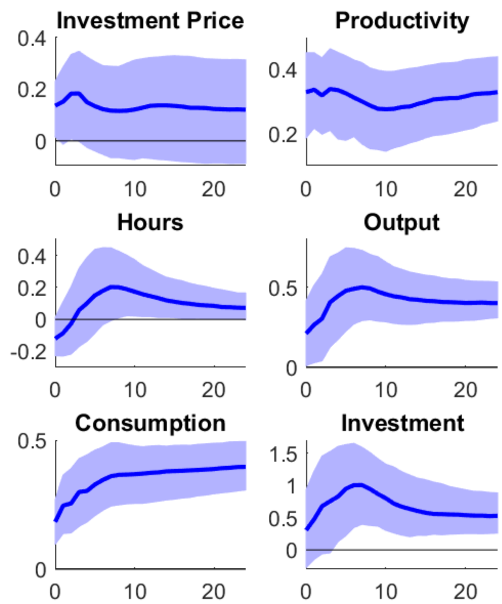
Figure 5 shows the responses to an immigration shock increasing the civilian population by about 0.2 pp in the long run. The results are as follows. Output, hours, and consumption show no clear response on impact. After 10 quarters, however, the response of output is significantly positive. Real wages fall on impact and remain significantly negative for about 10 quarters. Investment increases significantly after about 8 quarters with a peak rise of roughly 0.6 percent over the period displayed. Figure 9 in Appendix B shows that the responses to immigration shocks are robust to the inclusion of CPS revisions in $N_{2,t}$. The results are almost unchanged, when only revisions that can be exclusively linked to migration are included in $N_{2,t}$ (Figure 9).

[11] According to an ADF test with four lags the null hypothesis of a unit root in $N_{2,t}$ cannot be rejected with a p-value of 0.51.



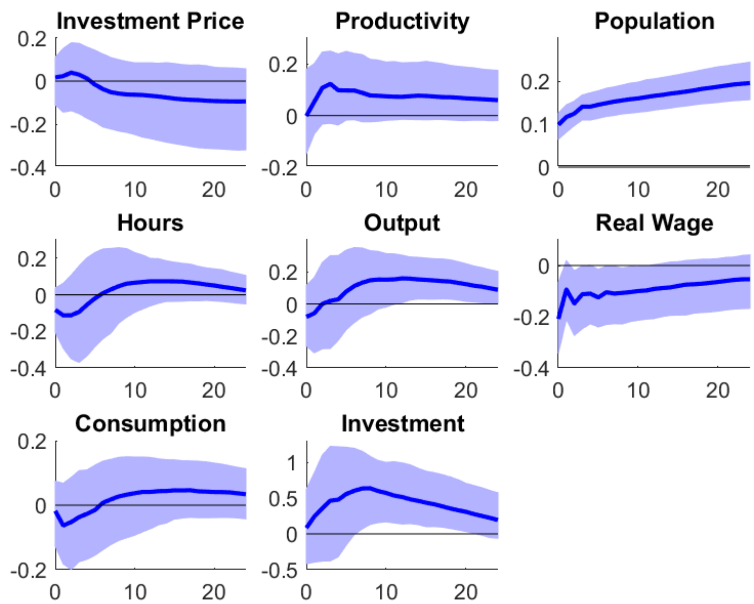
Solid lines: median responses. Shaded areas: 68% probability bands. Quarters on x-axis. Numbers in percent.

Figure 3: VAR Impulse Responses to an Investment Technology Shock



Solid lines: median responses. Shaded areas: 68% probability bands. Quarters on x-axis. Numbers in percent.

Figure 4: VAR Impulse Responses to a Neutral Technology Shock



Solid lines: median responses. Shaded areas: 68% probability bands. Quarters on x-axis. Numbers in percent.

Figure 5: VAR Impulse Responses to an Immigration Shock

Hours: levels vs. first differences One controversial choice that researchers face when identifying technology shocks by long-run restrictions is whether to include per-capita hours in levels (Christiano et al., 2003; Altig et al., 2011), or in first differences (Galí, 1999; Galí and Rabanal, 2004; Francis and Ramey, 2005). The short-run responses of output and hours to neutral technology shocks crucially depend on which specification is used. In the baseline estimation, I follow Fernald (2007) and correct for the common high-low-high-low pattern of productivity growth and hours in order to recover the business cycle effects of technology and immigration shocks. In the following, I check the robustness of the results with respect to the specification of hours. In the first case hours enter the VAR in levels ignoring structural breaks, in the second case hours enter the VAR in first differences. Figures 10 and 11 in Appendix B show the responses to investment technology, neutral technology, and immigration shocks, respectively. Most of the baseline results regarding immigration shocks are robust to the specification of hours. Real wages fall and investment increases, albeit the responses are associated with a larger uncertainty than in the baseline case.[12] Output remains flat, whereas the impact response of consumption is marginally negative in the difference specification.

[12]The responses are in general less precisely estimated under the alternative specifications.

Table 2: Forecast Error Variance Decomposition

	5 years			20 years		
Variable/Shock	Invest.	Neutral	Immigr.	Invest.	Neutral	Immig.
Investment Price	0.62	0.05	0.02	0.96	0.01	0.00
Productivity	0.09	0.40	0.08	0.45	0.39	0.03
Population	0.08	0.01	0.75	0.23	0.00	0.72
Hours	0.71	0.02	0.01	0.75	0.03	0.01
Output	0.43	0.18	0.03	0.63	0.23	0.01
Real Wage	0.03	0.77	0.04	0.09	0.74	0.01
Consumption	0.66	0.19	0.01	0.78	0.18	0.00
Investment	0.34	0.10	0.08	0.34	0.20	0.07

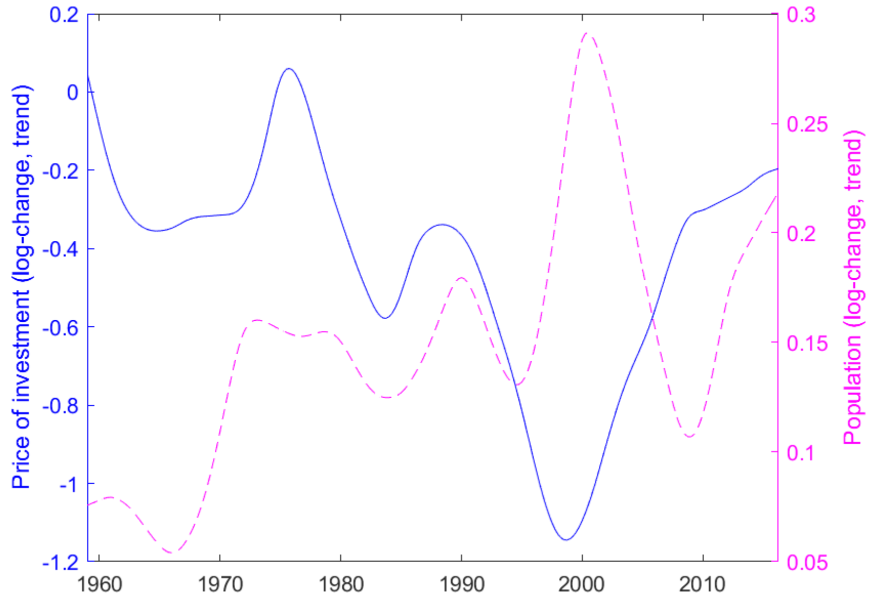
Interestingly, labor productivity increases in both robustness specifications after about one year.

Variance decomposition Table 2 presents the results of a forecast error variance decomposition. Three things stand out. First, technology shocks account for a large part of the variation of hours, output, real wages, consumption, and investment at business cycle frequencies ($\gg$40%), in line with the findings of Fisher (2006). Second, immigration shocks are of little importance ($<$10%) overall. This stands in contrast to Furlanetto and Robstad (2016), who find that immigration shocks in Norway have accounted for more than 50% of the variation in unemployment over all horizons and about 20% of the short-run variation in GDP. This is probably due to the fact that immigration rates have been considerably smaller in the United States than in Norway. Third, investment technology shocks account for 23% of the variation in immigration after 20 years. Interestingly, neutral technology shocks have no influence on immigration at all.

Investment price changes and immigration As noted by Fisher (2006), the decline in the relative price of investment accelerated during the late 1980s reaching a trough around the year 2000. At the same time, immigration to the US working age population significantly increased. This negative low-frequency correlation, at least during the period 1995-2010, between investment price changes and immigration is displayed in Figure 6, which compares the trend in the relative investment price changes (solid line) with the trend in immigration (dashed line) over the last five decades.

4 Conclusion

In this paper, I estimate the quarterly net flow of migrants to the US working age population using data from the Current Population Survey. I further estimate the effects of im-



Solid line (left axis): $\Delta \ln(P_t^I/P_t^Y)$. Dashed line (right axis): $\Delta \ln(N_{2,t})$. HP-filtered trend ($\lambda = 1600$).

Figure 6: Investment Price and Immigration to the United States

migration shocks in a vector autoregression. Immigration shocks are identified through long-run restrictions. The results are as follows. Immigration has a negative short-run impact on aggregate real wages, while there is a positive reaction of investment to immigration shocks. Most of the effects on the other variables are only marginally significant, or insignificant, depending on the specification of hours. Overall, immigration has had relatively little impact on the US economy. This finding contrasts with the attention that migration receives in political debates.

One possible extension of this paper would be to combine long-run and short-run (exclusion and/or sign) restrictions, in order to estimate the macroeconomic effects of immigration more precisely. I leave this for future research.

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A Data

Table 3: Population Data

VARIABLE	FREQUENCY	SOURCE
$CNP16OV_t$ [1]	monthly	BLS/CPS
$b_{t-16y,t}$	decennial	NCHS
$Births_{t-16y}$	monthly	NCHS
$Deaths_t$ [2]	annual	NCHS
$Revisions_t$		BLS/CPS
$Military_t$	quarterly	Cociuba et al. (2012)

$CNP16OV_t$ and $Births_t$ are seasonally adjusted using X-13 ARIMA-SEATS quarterly seasonal adjustment method. The numbers for $b_{t-16y,t}$ and $Deaths_t$ are interpolated to quarterly frequency. This is of course only an approximation. Given the absence of major epidemics, wars, etc. in recent decades, both series are probably very smooth at a quarterly frequency, though. The series $Military_t$ ends in 2011Q4. Numbers in previous years had been very small.

[1] Code: `LNU00000000`

[2] Only data for the population 15+ is available.

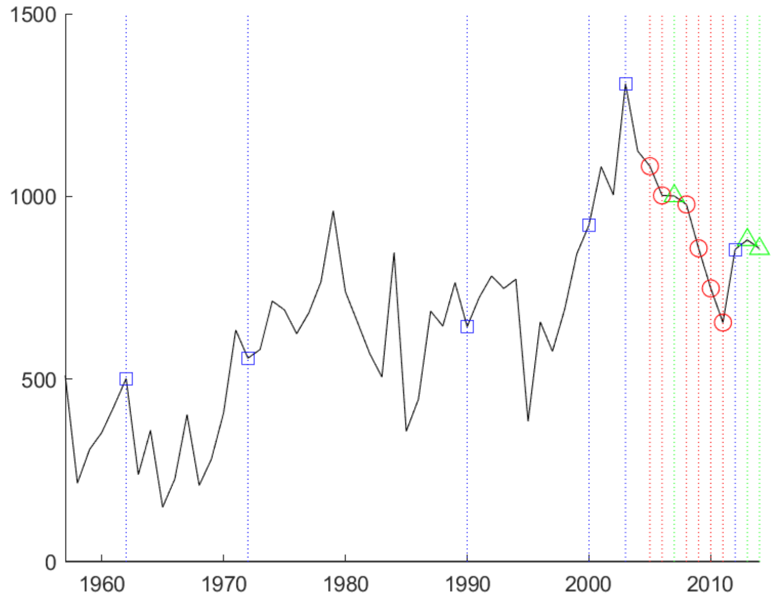
Table 4: CPS Data Revisions 1957-2016

Date	Number	Explanation	$\Delta N_{2,t}$	
January 1960	500,000	incl. Alaska and Hawaii		
January 1962	-50,000	1960 census	✓	
January 1972	800,000	1970 census	✓	
July 1975[3]	76,000	Vietnamese refugees	✓	✓
January 1986	400,000	undocumented immigrants and emigrants (legal) since 1980	✓	✓
January 1994	1,100,000	1990 census (adjustment effective in January 1990)	✓	
January 1997	470,000	updated information on immigrants	✓	✓
January 1999	310,000	updated information on immigrants	✓	✓
January 2000	2,600,000	2000 census	✓	
January 2003	941,000	2000 census	✓	
January 2004	-560,000	revised estimates of net international migration for 2000 - 2003	✓	✓
January 2005	-8,000	[4]	✓	
January 2006	-67,000	[4]	✓	
January 2007	321,000	[4]	✓	
January 2008	-745,000	[4]	✓	
January 2009	-483,000	[4]	✓	
January 2010	-258,000	[4]	✓	
January 2011	-347,000	[4]	✓	
January 2012	1,510,000	2010 census	✓	
January 2013	138,000	[4]	✓	
January 2014	2,000	[4]	✓	
January 2015	528,000	[4]	✓	
January 2016	265,000	[4]	✓	

Sources: Bureau of Labor Statistics (BLS), in *Employment and Earnings*, February 2006, 184-192.
BLS, "Adjustments to Household Survey Population Estimates in January 20XX".
Online: https://www.bls.gov/cps/documentation.html.

[3]Revision related to immigration in respective period. Fall of Saigon on April 30, 1975.

[4]Revised estimates of net international migration + updated vital statistics + methodological changes + other information.



Solid line: net migration to civilian population (excl. revisions). Vertical lines: CPS revision dates.[5] Annual numbers in thousand. Green triangles: upward revisions. Red circles: downward revisions. Blue squares: Census revisions. Sources: NCHS, BLS/CPS, DHS, Cociuba et al. (2012), and own calculations.

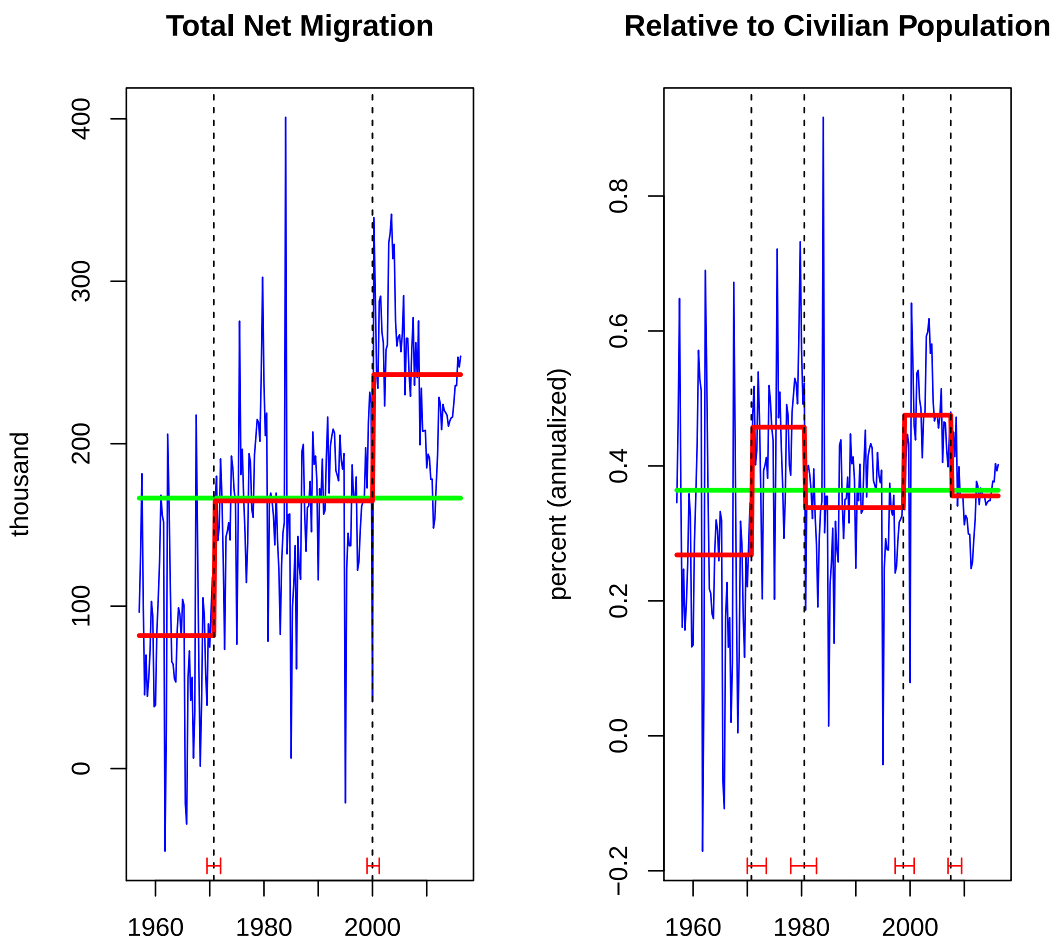
Figure 7: Immigration and CPS Revisions

[5]Revisions: January 1962, January 1972, January 1990/1994, January 2000, January 2003, January 2005 ff.

Table 5: Structural Breaks in US Immigration Series

Breaks			Dates			BIC
$\Delta N_{2,t}$						
$m = 0$						2745
$m = 1$	1970Q4					2640
$m = 2$	**1970Q4**			**2000Q1**		**2565**
$m = 3$	1970Q4			1998Q4	2007Q3	2568
$m = 4$	1970Q4	1980Q3		1998Q4	2007Q3	2575
$m = 5$	1970Q4	1980Q3	1989Q2	1998Q4	2007Q3	2584
$\Delta N_{2,t}/CNP16OV_{t-1}$						
$m = 0$						-241
$m = 1$	1970Q2					-266
$m = 2$	1970Q4	1980Q3				-267
$m = 3$	1970Q4	1980Q3		2000Q1		-271
$m = 4$	**1970Q4**	**1980Q3**		**1998Q4**	**2007Q3**	**-275**
$m = 5$	1970Q4	1980Q3	1989Q2	1998Q4	2007Q3	-264

Break dates are estimated using the Bai-Perron test (Bai and Perron, 2003).



Left: total net migration (in thousand, excl. revisions) to US civilian population. Right: percentage (annualized) contribution of net migration to total change of US civilian population (excl. revisions). The dotted vertical lines indicate the break dates; the horizontal lines at the bottom of the graph indicate their confidence intervals. Quarterly data. Source: own calculations.

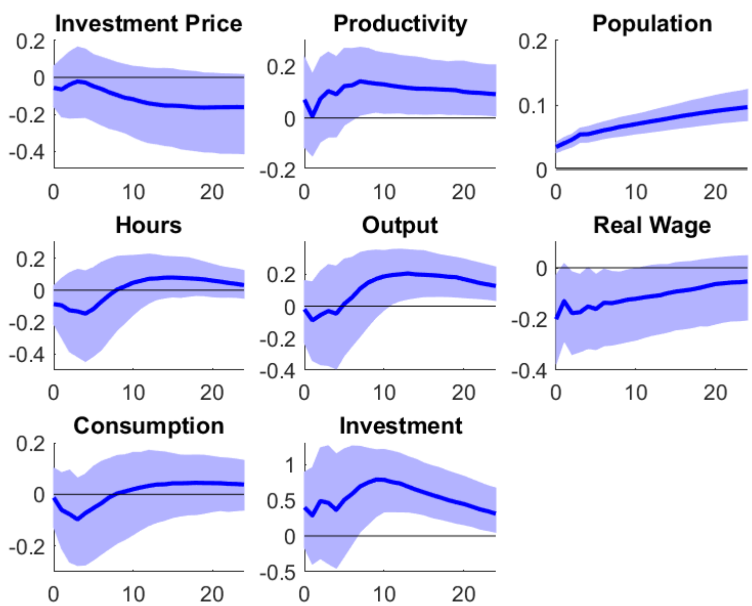
Figure 8: Structural Breaks in US Immigration Series

Table 6: Macroeconomic Data

Variable	Description	Code	Source
P_t^I	NRFI: Equipment, Implicit Price Deflator	Y033RD3Q086SBEA	BEA
P_t^Y	NFBS: Implicit Price Deflator	IPDNBS	BEA
Y_t	NFBS: Real Output	OUTNFB	BLS
$Hours_t$	NFBS: Hours of All Persons	HOANBS	BLS
W_t	NFBS: Compensation Per Hour	COMPNFB	BLS
P_t	GDP: Implicit Price Deflator	GDPDEF	BEA
C_t	PCE: Services	PCESV	BEA
	PCE: Nondurable Goods	PCEND	BEA
I_t	PCE: Durable Goods	PCEDG	BEA
	Gross Private Domestic Investment	GPDI	BEA

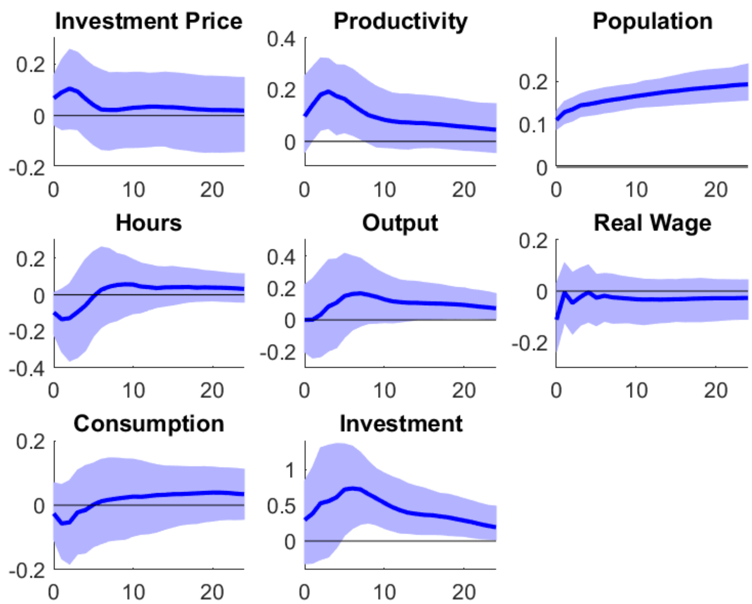
NRFI: Nonresidential Fixed Investment. NFBS: Nonfarm Business Sector. GDP: Gross Domestic Product. PCE: Personal Consumption Expenditures. Data retrieved from FRED, Federal Reserve Bank of St. Louis.

B Robustness



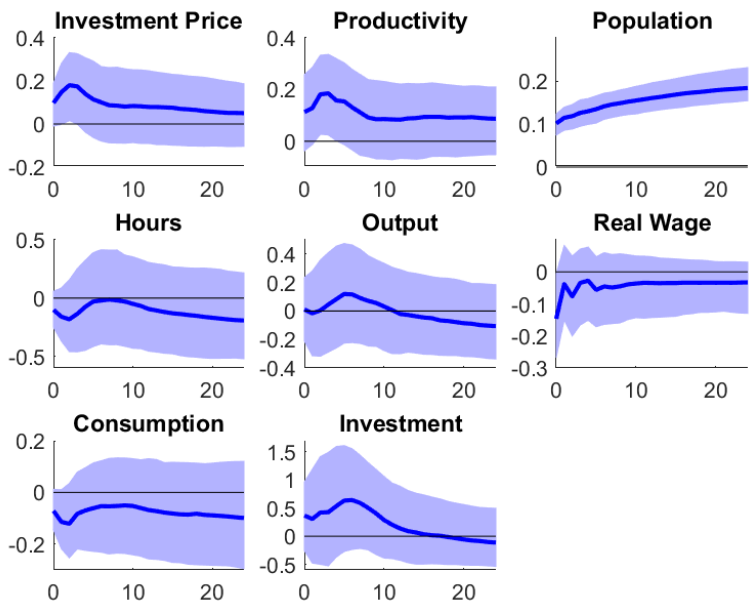
Solid lines: median responses. Shaded areas: 68% probability bands. Quarters on x-axis. Numbers in percent.

Figure 9: VAR Responses to an Immigration Shock - CPS Revisions



Solid lines: median responses. Shaded areas: 68% probability bands. Quarters on x-axis. Numbers in percent.

Figure 10: VAR Responses to an Immigration Shock - Hours in Levels (w/o Breaks)



Solid lines: median responses. Shaded areas: 68% probability bands. Quarters on x-axis. Numbers in percent.

Figure 11: VAR Responses to an Immigration Shock - Hours in First Differences