Slowdown in Immigration, Labor Market Shortages, and the Decline in the Skill-Premium (PRELIMINARY AND INCOMPLETE)*

Federico S. Mandelman
Federal Reserve Bank of Atlanta

Yang Yu
Shanghai Jiao Tong University

Francesco Zanetti
University of Oxford

Andrei Zlate
Federal Reserve Board

August 2022

Abstract

The pandemic put in evidence acute labor shortages in low-skilled occupations, which this paper claims were in the making for years. The housing bust that preceded the Great Recession along an increase in the enforcement of the U.S. southern border triggered a sharp decline in low-skilled immigration up to a point of reaching negligible levels on 2018. Consistently, wages for jobs at the bottom of the skill distribution notably outperformed past five years, reversing a steady increase in the skill premium that lasted for years. Immigrants are hard to substitute– as they tend to work in services that cannot be easily automated or offshored overseas– and therefore are prone to exacerbate production disruptions when they are short in supply. We develop a stochastic growth and use employment and wage data for different skill groups along border patrol enforcement and apprehensions at the U.S.-Mexico border to estimate the model and assess its fitness. Our analysis quantifies the output costs of restrictive migration and declining payoffs of costly education in the U.S. in this new scenario.

JEL classification: F16, F22, F41

Keywords: International labor migration, task upgrading, heterogeneous workers.

*The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Federal Reserve Bank of Atlanta, or the Federal Reserve System.

1 Introduction

Over years, vast amount of research has been devoted to an unequivocal fact: the steady increase in the skill premium in labor markets. This once cast-iron fact, however, showed a dramatic reversal in recent years (See Fig. 1a).[1]This result may not come as a surprise, however. During the pandemic, the most acute labor shortages and higher wage growth were precisely in occupations at the bottom of the bottom quartile of skill and earnings distribution (Fig. 2), with the top quartile being the visible laggard. Those with outsize gains are in service occupations (e.g., food service & hospitality workers, child care providers, home health aides), as well as, construction laborers. At the onset at the pandemic, these labor shortages were attributed to the fact these occupations had a higher contagion risk, since they mostly require to be in close contact with final costumers, with remote work not being an option. However, these labor shortages remained when the pandemic effects lingered –as vaccination became widespread. This suggests that more persistent structural factors may be behind this. Indeed, as observe in Fig. 1a and 2, the decline in the skill premium precedes the pandemic with a visible structural change around the year 2015.

We develop and estimate a structural model and show that these labor shortages were in the making for several years and were the result of a sustained turnaround international labor migration that started with the Great Recession. At first, these shortages were masked by the very slow recovery of employment in the aftermath of financial crisis, but they become visible as the labor market tightened in the last phase of the economic expansion cycle. For robustness, we also explore the behavior of automation (under capital skill-complementarity), and international trade/offshoring (including the rise of China), which has been linked to the increase in the skill premium over the past three decades. However, we find no structural changes in these two variables that can rationalize the skill premium reversal after 2015.

Measuring low-skilled immigration is not an easy task as it is mostly undocumented. The number of individuals being arrested (apprehended) by the U.S. patrol officers when attempting to illegally cross

[1] This figure shows the percentage differential between the annual wage increases college graduates and those with a high school degree (or less) receive.

the U.S./Mexico border, displayed in Fig. 3, is among the most widely used proxy for this variable in the literature. The series is volatile and is sensitive to the ups and downs of the business cycle on both sides of the border (see Mandelman and Zlate, 2012) but clearly shows a persistent decline after the peak of the U.S. housing boom in 2006, which last until 2018. The decline in immigration is actually more acute in the last part of the sample, once we take in consideration that the federal government devoted a higher number of U.S. border patrol officers' hours to the surveillance of the international border in recent years (see Fig. 4). Other things equal, this would have led to more arrests for a given number of attempted crossings. We can not ignore that there are two notable spikes in apprehensions (2019 and 2021), which break the downward trend studied here. We postpone a discussion of these two ongoing developments to the end of this paper. For now, we would just say that these dramatic jumps partly reflect post-pandemic policy changes along other one introduced during the Trump administration which may have weakened the statistical link between apprehensions and immigration flows. Moreover, as we emphasize throughout this study, changes in immigration take time to have a material effect in the U.S. labor markets.

The next point is linking immigrants to the occupations that suffered most acute shortages. Fig. 5a illustrates the change in the share of U.S. employment from 1980-2010 associated to 318 occupations ranked by skill level in the Census data. It shows that job gains were concentrated in the high-and low-skill occupations with a hollowing up of the middle.[2] This polarization of the labor market has been widely studied in the literature (seminal contributions include, Acemoglu and Autor, 2011, and Jaimovich and Siu, 2020). However, this polarization breaks down once we split the sample between native and foreign workers (see Fig. 5b). For natives, all job gains where concentrated on high skill occupations. Job creation at the very bottom of the skilled distribution instead is explained by foreign-born workers which migrated to the U.S. in large numbers after 1980.[3] Fig. 5c, in turn, shows that most low-skilled jobs cre-

[2]The skill rank is is approximated by the initial average wage in each occupation. See Acemoglu and Autor (2011) and Autor and Dorn (2013) for data and references.

[3]Grogger and Hanson (2011) show that the the share of foreign-born in the U.S. population more than doubled (from 6% to 13%) from 1980-2010.

ated correspond to the "service occupations" mentioned above.[4] It is not a surprise that immigration is linked with these occupations. These jobs require to be in close contact with final customer so they cannot be offshored overseas, being immigration the only alternative. Moreover, these jobs require to interacting with humans and manual handling, limiting the scope of automation. Finally, it is worth highlighting that the decline in the value of skills in the labor market occurred in sync with a decline in the inflation adjusted price of education (tuition and fees). Refer to Fig. 1b. If the demand for skills is sensitive to the economic return on education, the slowdown in immigration may have other repercussions. Lower immigration boost natives' low-skill wages, and may discourage them from paying costly education to move up in the skill ladder, ultimately decreasing aggregate labor productivity and output.

Our model consists of tractable stochastic growth framework that features skill heterogeneity low-skill labor migration within a general equilibrium context. It also includes the possibility of offshoring of labor tasks through international trade and, in the extended version, automation. These last two are the other factors associated with developments in the skill premium. The model consists of two large economies (Home and Foreign) that trade with each other and are financially integrated, as well as a third small economy (South) that is the source of low-skill immigrant. In this dynamic specification, the households' optimization behavior endogenously determines not only the extent of offshoring, migration, and automation, but also, the optimal degree of skill acquisition in response to these changes. The model, which captures short- to medium-run dynamics in addition to long-term growth, is estimated with quarterly data on output (U.S., Mexico and the rest of the world), employment by different skill groups, and U.S. border patrol enforcement at the US-Mexico border. The latter series captures the stance of U.S. immigration policy, which tends to vary with the political cycle. Finally, to validate the model predictions, we use proxies measuring the evolution of offshoring costs and undocumented immigration inflows. In the extended version, we include automation with capital/skill complementarity and use information-and-communications-technology (ICT) capital and time-varying depreciation data to estimate it.

[4]We repeat the empirical strategy in Autor and Dorn (2013) by considering a simple counterfactual scenario, in which employment in service occupations is held at its original level from 1980. Like in their results, the twist of the employment distribution at the low-skill tail becomes negligible in this counterfactual scenario.

One key feature of our model is the presence of trade in labor tasks rather than in finished goods. Due to remarkable declines in transportation and communication costs, international trade increasingly facilitates breaking down the production process into separate tasks executed at different locations.[5] The decline in offshoring costs induces countries to specialize in their most skilled labor tasks, thereby increasing aggregate labor productivity. This productivity is enhanced with the complementarity of these skilled tasks with automated capital in the extended model. As a result, aggregate income increases, and so does the demand for non-tradable services provided by low-skill natives and immigrants. Most notably, our model features endogenous arrival of low-skill immigrant workers from the South, which boosts labor supply but dampens wages for this skill group. Households can freely allocate low-skill labor to the non-tradable service, or alternatively can invest in training to upgrade their skills and work in middle- and high-skill occupations in response to changes in the economic environment. In this setup, training involves an irreversible sunk cost with initial uncertainty concerning the future idiosyncratic productivity.

Our structural model approach allows us to assess quantitatively the welfare effect of changes in migration policy the estimated framework. Abstracting from income distributional issues across workers of different skill levels, we find that lowering migration the well-being of the representative native household. Although immigration lowers wages at the bottom of the skill distribution, it also provides benefits that offset these losses. First, cheaper services improve households' purchasing power. Second, by dampening the increase in low-skill wages, immigration incentivizes natives to train and move up in the skill ladder, which ultimately increases labor productivity. The estimated model is used to estimate the welfare impact of labor shortages during the pandemic. In particular, we assess the impact of surge in consumer demand associated with the several rounds of stimulus payments that began with the CARES act. We find acute welfare losses associated and much higher consumer prices due to the low degree of substitutability of low-skill labor in short supply (as automation and offshoring of their tasks is precluded).

[5]To illustrate this idea with an example, as trade links deepen, U.S. multinationals can employ professionals in the Silicon Valley area to work on the design of a state-of-the-art computer device, while other productive tasks can be accomplished in the rest of the world (e.g., Indian programmers perfect the software, Japanese technicians provide the microchips, and Chinese workers proceed with the final assembly).

Related literature The evidence brought by existing literature appears consistent with our claim that immigration plays an important role driving the employment and wage dynamics in the U.S. labor market. [6]. Grogger and Hanson (2011) show that the share of foreign-born in the U.S. population more than doubled (from 6% to 13%) since the 1980s. Peri and Sparber (2009) indicate that a disproportionate number of these immigrants were relatively low-skilled. Ottaviano and Peri (2012), Borjas et al. (2008), and Friedberg and Hunt (1995) document a negative impact of migration in low-skill wages and native employment. Cortes (2008) finds that the inflow of low-skill migrants into the U.S. lowers the price of services provided by low-skill occupations. In turn, Autor and Dorn (2013) focus their analysis on employment at the left tail of the skill distribution, showing that the employment growth in low-skill occupations is accounted by the emergence of "service occupations." Hunt (2012) and Jackson (2015) show that low-skill immigration is associated with higher educational attainment among natives.[7] Finally, our paper complements existing closed-economy models in which routine-biased technological change is the factor driving employment polarization. Autor and Acemouglu (2011) and Jaimovich and Siu (2020) are some notable examples. As in the case of offshoring, these papers show that automation has also contributed to the disappearance of routine-intensive jobs in the middle of the skill distribution.[8]

The modelling of offshoring is based on the model with trade in tasks developed by Grossman and Rossi-Hansberg (2008), which we expand to include a continuum of tasks executed by heterogeneous workers in a dynamic general equilibrium setting as in Mandelman (2016).[9] In turn, labor migration is subject to a sunk migrations cost as in Mandelman and Zlate (2012). Our paper is adjacent to Ottaviano et al. (2013), which is the first paper to study immigration and offshoring within a unified framework of labor tasks. Using data from the U.S. manufacturing sector, they find that immigrant and native workers

[6]Ottaviano et al. (2013) and Wright (2014) corroborate that the offshoring of middle-skill tasks brings cost savings that enhance the productivity of the high-skilled. Crinò (2010) shows that offshoring is also pervasive in white-collar occupations like accounting, bookkeeping, and customer services.

[7]In addition, di Giovanni et al. (2015), Kennan (2013), Klein and Ventura (2009), and Mandelman and Zlate (2012) develop general equilibrium models of international labor migration, finding welfare gains from reducing immigration barriers.

[8]The empirical literature provides evidence that both offshoring and skill-biased technological change have contributed to the polarization of U.S. employment over the past three decades (Firpo et al., 2011). Either offshoring or skill-biased technological change would interact similarly with the mechanism of endogenous low-skilled immigration that we propose.

[9]The modeling of worker heterogeneity across skills resembles the framework with firm heterogeneity across productivity levels proposed in Ghironi and Melitz (2005), which is also used to model offshoring through vertical FDI in Zlate (2016).

tend to perform tasks at different ends of the task complexity spectrum, while offshore workers perform tasks in the middle portion of the spectrum. Finally, this paper is closely related to Mandelman and Zlate (2022) which also assesses the role of automation, offshoring, and automation using a model of trade in tasks. There are some notable differences, however. The previous paper consisted of a two country model in which labor immigration was taken as given. In this model, migration decisions are derived from the optimization problem of households at a third country (South). To estimate the model, we use border enforcement, migrants' apprehensions, and macroeconomic data from Mexico. None of these data series were used in the cited paper. Moreover, the previous paper was deterministic in nature and only allowed for the analysis of long-run transition dynamics. The stochastic growth model in this paper allows to explore short-run dynamics following transitory shocks which are needed for the identification of structural parameters. This approach give us the flexibility to study, for instance, how the housing boom-bust and the change in the political cycle may have reversed he migration tide. All this is needed to explain the reversal in the skill premium, which is at the center of this new study (the time span considered in the previous paper concluded in 2013). In the previous work the cost of skill acquisition is fixed, while now is time-varying and matched with the actual evidence. Finally, in this study we made a welfare analysis of alternative migration policies, which is absent in the previous work.

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 presents the data and model estimation results. Section 4 evaluates the model fit and quantifies the impact of various shocks to growth dynamics. Section 5 assess the welfare implications of alternative trade and immigration policies. Section 6 concludes.

2 Model

Our model consists of two large economies (Home and Foreign), and also a third small economy (South) that neighbors Home. In this section, the discussion is focused mainly on the Home and South economies.

For Foreign, the equations are similar to those for Home, and its variables are marked with an asterisk.[10] Since this paper is focused on the labor market outcomes from offshoring and immigration, we abstract from capital and have labor as the only factor of production. We start with a description of the production sector, and then proceed with the household sector in Home. Then we describe the South economy, which is the source of immigrant labor into Home. The appendix describes the system of equations that characterize all the equilibrium conditions of the model as well as the auxiliary equations needed to make the model comparable with the data.

2.1 Production

There are two sectors in the Home economy. The first sector produces services, which are non-tradable by definition and require native and immigrant unskilled labor. This service sector captures the service occupations that require either close contact with the final consumer or need to be executed where the final service is delivered. The second sector produces a country-specific final good, which is obtained from the aggregation of a continuum of diverse labor tasks. These tasks can be either executed at Home or offshored to Foreign. Workers in this sector are heterogeneous in skill, which they acquire after undergoing training. In short, we will refer to this sector as the "tradable" sector. Notice, however, that the meaning of tradability is different from the one typically encountered in the literature. Here, the tasks needed to produce the final goods, rather than the finals goods themselves, are traded internationally.

Non-Tradable Sector The first sector produces services that are non-tradable by definition. The labor input used in production, $L^A_{N,t}$, is a CES composite of aggregate units of unskilled (raw) labor, $L_{N,t}$, and immigrant labor, $L^s_{\mathbf{i},t}$:

$$L^A_{N,t} = \left[\alpha \left(L_{N,t} \right)^{\frac{\sigma_N - 1}{\sigma_N}} + (1-\alpha) \left(L^s_{\mathbf{i},t} \right)^{\frac{\sigma_N - 1}{\sigma_N}} \right]^{\frac{\sigma_N}{\sigma_N - 1}}.$$

Output is a linear function of this labor input: $Y_{N,t} = \mathbb{X}_t L^A_{N,t}$. $\mathbb{X}_t$ is a stochastic permanent world

[10] The model is symmetric for Home and Foreign, with the only exception being that Home receives immigrant low-skill labor from the South, whereas Foreign does not.

technology shock that affects all productive sectors in all countries. This global shock displays a unit-root and warrants a balanced-growth path for the economy. The price of this service good is $P_{N,t}$. The profit maximization problem implies the following expressions for the wages of low-skill native and immigrant labor: $w_{\mathbf{u},t} = P_{N,t}\mathbb{X}_t\alpha \left(L^A_{N,t}/L_{N,t}\right)^{1/\sigma_N}$ and $w_{\mathbf{i},t} = P_{N,t}\mathbb{X}_t(1-\alpha)\left(L^A_{N,t}/L^s_{\mathbf{i},t}\right)^{1/\sigma_N}$.

Tradable sector The tradable sector employs a continuum of skilled workers executing different labor tasks. In order to obtain the skill required for employment in the tradable sector, households invest in training every period. The cost of training involves an irreversible sunk cost and results in an idiosyncratic productivity level $\mathbf{z}$ for each worker.[11] Workers draw this idiosyncratic productivity from a common distribution $\mathcal{F}(\mathbf{z})$ over the support interval $[1, \infty)$ upon completion of training. The raw labor provided by each worker is augmented by idiosyncratic productivity and expressed in efficiency units as follows: $l_{\mathbf{z},t} = \mathbf{z}l_t$, where l_t indicates units of raw labor. Idiosyncratic productivity $\mathbf{z}$ remains fixed thereafter, until an exogenous skill destruction shock makes the skill obtained from training obsolete, transforming the efficiency units back into units of raw labor. The skill destruction shock is independent of the workers' idiosyncratic productivity level, so $\mathcal{F}(\mathbf{z})$ characterizes the efficiency distribution for all trained native workers at any point in time. The household's training decision is described in more detail further below.

The efficiency units of labor benefit from two technological innovations when used in production. One is the world productivity shock, $\mathbb{X}_t$, and the other is a temporary country-specific technology shock, ε^Z_t, that evolves as an AR(1) process. As a result, each efficiency unit of labor supplied is transformed in a production task, $n_t(\mathbf{z})$, as follows:

$$n_t(\mathbf{z}) = (\mathbb{X}_t\varepsilon^Z_t)l_{\mathbf{z},t} = (\mathbb{X}_t\varepsilon^Z_t)\mathbf{z}l_t. \tag{1}$$

Trained workers obtain skills and are employed in a variety of occupations, and each of these occupa-

[11] The functional form of the sunk cost will be described later.

tions allows them to execute a given set of tasks ξ, which are defined over a continuum of tasks Ξ (i.e., $\xi \in \Xi$). At any given time, only a subset of these tasks Ξ_t ($\Xi_t \subset \Xi$) may be demanded by firms in the global labor market and effectively used in production.[12] The labor input of the tradable sector is obtained by aggregating over a continuum of tasks $n_t(\mathbf{z}, \xi)$ that are imperfect substitutes: $\mathbb{N}_t = \left[\int_{\xi \epsilon \Xi_t} n_t(\mathbf{z}, \xi)^{\frac{\theta-1}{\theta}} d\xi \right]^{\frac{\theta}{\theta-1}}$, where $\theta > 1$ is the elasticity of substitution across tasks.[13] The wage bill is $\mathbb{W}_t = \left[\int_{\xi \epsilon \Xi_t} w_t(\mathbf{z}, \xi)^{1-\theta} d\xi \right]^{\frac{1}{1-\theta}}$, where $w_t(\mathbf{z}, \xi)$ is the wage paid to each efficiency unit of labor. Importantly, some of these tasks may be executed in Foreign, as described in more detail below.

With labor as the only input in production, the final tradable good is $Y_{T,t} = \mathbb{N}_t$, and the price of this final good is $P_{T,t} = \mathbb{W}_t$. The price of this tradable good is the numeraire, $P_{T,t} = \mathbb{W}_t \equiv 1$.

Trade in Tasks and the Skill Income Premium In a symmetric equilibrium, the wage paid to each worker in the tradable sector is skill-specific. That is, $w_t(\mathbf{z}, \xi) = w_t(\mathbf{z}, .)$ for every task $\xi \in \Xi$. The skill premium $\pi_{D,t}$ in the domestic tradable sector is defined as the difference between the income obtained from a task executed for this sector and the income obtained by a raw unit of labor in the non-tradable sector:

$$\pi_{D,t}(\mathbf{z}, .) = w_{D,t}(\mathbf{z}, .) n_{D,t}(\mathbf{z}, .) - w_{\mathbf{u},t} l_t, \tag{2}$$

where $n_{D,t}(\mathbf{z}, .)$ denotes the task produced by one efficiency unit of labor in the tradable sector for the home market, and $w_{D,t}(\mathbf{z}, .)$ is the associated wage.

Some of the tasks imbedded in the Home final good are executed in Foreign and imported (i.e., they are offshored by the Home economy to Foreign). Conversely, Foreign demands some of the tasks executed in Home. To be delivered to Foreign, the tasks executed in Home are subject to an iceberg offshoring cost $\tau \geqslant 1$ and also to a period-by-period fixed offshoring cost f_o, which is defined in terms of efficiency units of labor.[14] For consistency with the economy-wide balanced growth path, this fixed cost is augmented by the world technology shock, then expressed in units of the Home numeraire as follows: $f_{o,t} = \frac{w_{\mathbf{u},t}}{(\mathbb{X}_t \varepsilon_t^Z)} (\mathbb{X}_t f_o)$.

[12] The subset of tasks demanded by foreign companies is $\Xi_t^* \subset \Xi$, and may differ from Ξ_t

[13] See Itskhoki (2008) for a similar aggregation of heterogeneous labor inputs.

[14] The modelling of offshoring costs closely resemble the framework characterizing trade costs in Ghironi and Melitz (2005).

Changes in offshoring costs are reflected in shocks ε_t^{τ} to the level of the iceberg cost τ, so that $\tau_t = \varepsilon_t^{\tau}\tau$. The skill premium gap, $\pi_{X,t}$, for executing a task for Foreign is:

$$\pi_{X,t}(\mathbf{z},.) = \left(\frac{w_{X,t}(\mathbf{z},.)}{\tau_t} n_{X,t}(\mathbf{z},.) - f_{o,t}\right) - w_{\mathbf{u},t} l_t. \tag{3}$$

Thus, all Home workers have their tasks sold domestically. However, due to the iceberg trade cost and the fixed offshoring cost, only the most efficient Home workers execute tasks for Foreign.[15] Thus, a worker will take part in multinational production as long as the idiosyncratic productivity level $\mathbf{z}$ is above a threshold $\mathbf{z}_{X,t} = \inf\{\mathbf{z} : \pi_{X,t}(\mathbf{z},.) > 0\}$. Conversely, home workers with productivity below $\mathbf{z}_{X,t}$ execute tasks for the domestic market only. A decrease in offshoring cost allows multinationals to assign more tasks to the most productive workers in Home and Foreign. This process enhances cross-country task specialization while displacing less skilled workers, and it is consistent with the evidence that inequality deepens in countries that lower their barriers to trade, irrespective of their degree of economic development.[16] Shocks to aggregate productivity, demand, and the iceberg trade cost will also result in changes to the threshold level $\mathbf{z}_{X,t}$.

To solve the model with heterogeneous workers, it is useful to define average productivity levels for two representative groups, as in Melitz (2003). First, the average productivity of all workers is: $\tilde{\mathbf{z}}_{D,t} \equiv \left[\int_{\mathbf{1}}^{\infty} \mathbf{z}^{\theta-1} d\mathcal{F}(\mathbf{z})\right]^{\frac{1}{\theta-1}}$. Second, the average efficiency of the workers whose tasks are traded globally is: $\tilde{\mathbf{z}}_{X,t} \equiv \left[\frac{1}{1-\mathcal{F}(\mathbf{z}_{x,t})} \int_{\mathbf{z}_{x,t}}^{\infty} \mathbf{z}^{\theta-1} d\mathcal{F}(\mathbf{z})\right]^{\frac{1}{\theta-1}}$. Thus, our original setup is isomorphic to one where a mass of workers $N_{D,t}$ with average productivity $\tilde{\mathbf{z}}_{D,t}$ execute tasks for the domestic market. Within this group, a mass of high-skilled workers $N_{X,t}$ with average productivity $\tilde{\mathbf{z}}_{X,t}$ accomplish tasks for the foreign market in addition to the domestic market. In addition, we define the mass of middle-skill workers who execute tasks exclusively for the domestic market as $N_{M,t} = N_{D,t} - N_{X,t}$. The wages for each skill group are $\tilde{w}_{D,t} = w_{D,t}(\tilde{\mathbf{z}}_{D,t},.)$ and $\tilde{w}_{X,t} = w_{X,t}(\tilde{\mathbf{z}}_{X,t},.)$. Similarly, their associated skill premia for each

[15]See Krishna et al. (2014) for evidence supporting this result.

[16]This implication contrasts with that of the traditional Hechsher-Ohlin/Stolper-Samuelson paradigm, which predicts a decrease in the skill premium in countries with abundant unskilled labor. See Burstein and Vogel (2016) and Goldberg and Pavcnik (2007) for a related discussion.

grup are $\tilde{\pi}_{D,t} = \pi_{D,t}(\tilde{\mathbf{z}}_{D,t},.)$ and $\tilde{\pi}_{X,t} = \pi_{X,t}(\tilde{\mathbf{z}}_{X,t},.)$. Finally, the average skill premium is defined as: $\tilde{\pi}_t = (N_{D,t}\tilde{\pi}_{D,t} + N_{X,t}\tilde{\pi}_{X,t})/N_{D,t}$. Taking all these into account, the wage bill of the home tradable sector can be re-written as: $\mathbb{W}_t = \left[N_{D,t}\left(\tilde{w}_{D,t}\right)^{1-\theta} + N^*_{X,t}\left(\tilde{w}^*_{X,t}\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}$, where $N^*_{X,t}$ denotes foreign workers executing tasks imported by Home, and $\tilde{w}^*_{X,t}$ is the corresponding wage expressed in units of the Home numeraire.

For simplicity in the exposition, we assume that the distribution of idiosyncratic productivity in Home and Foreign is symmetric. However, it would be feasible to rationalize a scenario with two countries at different stages of economic development in this context. For instance, the distribution of idiosyncratic productivity in Home may stochastically dominate the one characterizing Foreign –i.e. $\mathcal{F}(\mathbf{z}) > \mathcal{F}^*(\mathbf{z})$. Therefore, workers at the top of the skill distribution in Foreign may have the same productivity as some of the workers in the middle of the skill distribution in Home. Notice, however, that same productivity across countries does not imply same wages in equilibrium. Consistent with the Balassa-Samuelson hypothesis, countries with higher average productivity in the tradable sector pay higher wages to low productivity workers in a sector that is either non-tradable or subject to trade costs. These wage differentials foster the offshoring of tasks despite low productivity in Foreign. All these modifications would have a level effect on output and wages in stationary equilibrium, without significantly altering the growth dynamics and the intuition of the model results.[17]

2.2 Household

Household members form an extended family and pool their labor income – obtained from working in the tradable and non-tradable sectors – and choose aggregate variables to maximize expected lifetime utility. As in Andolfatto (1996), the model assumes that household members perfectly insure each other against fluctuations in labor income resulting from changes in their employment status. This assumption eliminates any type of ex-post heterogeneity across workers at then household level.

[17] Results for the asymmetric model are available upon request. Note that the offshoring of tasks is much more sizable between advanced economies at similar stages of development, than between advanced and developing economies (see Grossman and Rossi-Hansberg, 2012).

Consumption Household's consumption basket is: $C_t = \left[(\gamma_c)^{\frac{1}{\rho_c}} (C_{T,t})^{\frac{\rho_c - 1}{\rho_c}} + (1-\gamma)^{\frac{1}{\rho_c}} (C_{N,t})^{\frac{\rho_c-1}{\rho_c}} \right]^{\frac{\rho_c}{\rho_c - 1}}$, which includes amounts of the final good $C_{T,t}$ and the non-tradable personal services $C_{N,t}$. The consumer price index is: $P_t = \left[\gamma_c + (1-\gamma_c)(P_{N,t})^{1-\rho_c} \right]$. The final good produced in the tradable sector in Home, $Y_{T,t}$, is a composite of domestic and foreign tasks. It is entirely used for consumption by the Home household, $C_{T,t}$, and also by the Southern immigrant workers established in Home, $C^s_{T,t}$, so that $Y_{T,t} = C_{T,t} + C^s_{T,t}$. The problem of the Southern household is described in Section 2.3.

Household's Problem The household has standard additive separable utility over real consumption, C_t, and leisure, $1 - L_t$, where L_t is the aggregate supply of raw labor. They maximize a standard utility kernel, which is modified to be consistent with the balanced growth-path[18]:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} \varepsilon_t^b \left[\frac{1}{1-\gamma} C_t^{1-\gamma} - a_n \mathbb{X}_t^{1-\gamma} \frac{L_t^{1+\gamma_n}}{1+\gamma_n} \right], \tag{4}$$

where parameter $\beta \in (0,1)$ is the subjective discount factor, $\gamma > 0$ is the inverse inter-temporal elasticity of substitution, $\gamma_n > 0$ is the inverse of the Frisch elasticity of labor supply, and $a_n > 0$ is the weight on the disutility from labor. Also, ε_t^b is an AR(1) shock to the intertemporal rate of substitution, which may be interpreted as a consumption demand shock.

The period budget constraint expressed in units of the numeraire good is:

$$w_{\mathbf{u},t} L_t + \pi_t N_{D,t} = f_{j,t} N_{E,t} + P_t C_t + q_t B_t - B_{t-1} + \Phi(B_t). \tag{5}$$

Total income is captured by the three terms of the left-hand side. The first term, $w_{\mathbf{u},t} L_t$, captures the remuneration of all raw units of labor, which includes the income of unskilled labor employed in the non-tradable service sector, as well as the "shadow" income generated by the raw labor that undergoes training and works in the tradable sector. The second term captures the total skill income premium that

[18] See Rudebusch and Swanson (2012).

results from training and selling tasks domestically, defined as the product between the total measure of skilled workers, $N_{D,t}$, and their average skill income premium, π_t as defined above.

On the right-hand side of (5), the first term represents the total investment in training, in which $N_{E,t}$ are the new skilled occupations created at time t, and $f_{j,t}$ is the sunk training cost required for each of these new skilled workers. Training costs are time-varying and are subject to AR(1) type cost-push shocks ε_t^{Tr} such that: $f_{j,t} = \left(\varepsilon_t^{Tr} f_j\right)^{\Theta}$, where Θ is defined as the elasticity of total training to costs to observed tuition costs, which will be estimated below.[19] Like offshoring costs, these costs also require a path consistent with balanced-growth.[20] The newly-created skilled workers $N_{E,t}$ join the already-existing $N_{D,t}$, and together are subject to a skill destruction shock δ, that renders the skills obtained from training obsolete. Therefore, the resulting law of motion for the skilled workers is: $N_{D,t} = (1-\delta)(N_{D,t-1} + N_{E,t-1})$. International financial transactions are restricted to a one-period, risk free bond. The level of debt due every period is B_{t-1}, and the new debt contracted is B_t at price $q_t = 1/(1+r_t)$, with r_t representing the implicit interest rate. To induce model stationarity, we introduce an arbitrarily small cost of debt, $\Phi(.)$, which takes the following functional form: $\Phi(B_t) = \mathbb{X}_t \frac{\phi}{2}\left(\frac{B_t}{\mathbb{X}_t}\right)^2$. It is necessary to include the level of global technology in the numerator and the denominator of this functional specification, in order to guarantee stationary along the balanced growth path.[21]

Optimality Conditions The household maximizes utility subject to its budget constraint and the law of motion for skilled workers described above. The optimality conditions for labor effort and consumption/saving are conventional:

$$\hat{a}_n (L_t)^{\gamma_n} (C_t)^{\gamma} = \frac{w_{\mathbf{u},t}}{P_t}, \tag{6}$$

$$q_t = \beta E_t \left\{ \frac{\zeta_{t+1}}{\zeta_t} \right\} - \Phi'(B_t), \tag{7}$$

[19] Implicitly, there is some possibility of substitution (e.g., from private to public education), alternative career paths. Scholarships and grants became more relevant during the period considered here.

[20] This sunk cost is expressed in units of the numeraire good as: $f_{j,t} = \frac{w_{\mathbf{u},t}}{(\mathbb{X}_t \varepsilon_t^Z)}(\mathbb{X}_t f_{j,t})$.

[21] In the balanced growth path, debt B_t grows in sync with technology $\mathbb{X}_t$, making the ratio stationary. Therefore, the adjustment cost must grow at the same rate. See Rabanal et al. (2011).

where $\hat{a}_n = a_n \mathbb{X}_t^{1-\gamma}$, and $\zeta_t = \varepsilon_t^b (C_t)^{-\gamma} / P_t$ characterizes the marginal utility of consumption. The optimality governing the choice of bonds for foreign households in conjunction with the Euler equation in (7) yields the following risk-sharing condition:

$$E_t \left\{ \frac{\zeta_{t+1}^*}{\zeta_t^*} \frac{\mathbb{Q}_t}{\mathbb{Q}_{t+1}} - \frac{\zeta_{t+1}}{\zeta_t} \right\} = -\frac{\Phi'(B_t)}{\beta}, \tag{8}$$

where $\mathbb{Q}_t$ is the factor-based real exchange rate (or terms of labor).[22] Finally, the optimality condition for training is pinned down by the following condition:

$$f_{j,t} = \mathbb{E}_t \sum_{s=t+1}^{\infty} [\beta (1-\delta)]^{s-t} \left(\frac{\zeta_s}{\zeta_t} \right) \tilde{\pi}_s, \tag{9}$$

This equilibrium condition shows the trade-off between the sunk training cost $f_{j,t}$ and the present discounted value of the future skill premia resulting from the creation of a new skilled occupations $\{\tilde{\pi}_s\}_{s=t+1}^{\infty}$ adjusted for the probability of skill destruction δ.

2.3 South Economy

The representative household in South provides raw labor without the possibility of training. This labor can either be employed in domestic production or emigrate to Home after incurring a sunk migration cost. The household members pool their total income, which is obtained from both domestic and emigrant labor, and choose aggregate variables to maximize lifetime utility.

Labor Migration The representative household supplies a total of $L_{\mathbf{u},t}^s$ units of raw labor every period. A portion of the household members $L_{\mathbf{i},t}^s$ reside and work as low-skill immigrant workers abroad (in Home). The remaining $L_{\mathbf{u},t}^s - L_{\mathbf{i},t}^s$ work in the country of origin (in South). The calibration ensures that the low-skill wage in Home is higher than the wage in South, so that the incentive to emigrate from

[22]That is, $\mathbb{Q}_t = \frac{\varepsilon \mathbb{W}_t^*}{\mathbb{W}_t}$. Thus, the real exchange rate is expressed in units of the foreign numeraire per units of the home one, where ε is the nominal exchange rate.

South to Home exists every period. However, a fraction of total labor supply always remains in South ($0 < L^s_{\mathbf{i},t} < L^s_{\mathbf{u},t}$). The macroeconomic shocks are small enough for these conditions to hold in every period.

The household sends an amount $L^s_{\mathbf{e},t}$ of new emigrant labor to Home every period, where the stock of immigrant labor $L^s_{\mathbf{i},t}$ is built gradually over time. The time-to-build assumption in place implies that the new immigrants start working one period after arriving. They continue to work in all subsequent periods until a return-inducing exogenous shock, which hits with probability δ_l every period, forces them to return to South. This shock reflects issues such as termination of employment in the destination economy, likelihood of deportation, or voluntary return to the country of origin, etc.[23] The resulting rule of motion for the stock of immigrant labor in Home is: $L^s_{\mathbf{i},t} = (1-\delta_l)(L^s_{\mathbf{i},t-1} + L^s_{\mathbf{e},t})$.

Household's Decision Problem The household maximizes lifetime utility, as described above:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{1}{1-\gamma} (C^s_t)^{1-\gamma} - a^s_n \mathbb{X}_t^{1-\gamma} \frac{(L^s_{\mathbf{u},t})^{1+\gamma_n}}{1+\gamma_n} \right], \tag{10}$$

subject to the law of motion for immigrant labor and the budget constraint:

$$w_{\mathbf{i},t} L^s_{\mathbf{i},t} + w^s_{\mathbf{u},t} \left(L^s_{\mathbf{u},t} - L^s_{\mathbf{i},t} \right) \geqslant f_{e,t} L^s_{\mathbf{e},t} + P^s_t C^s_t, \tag{11}$$

where $w_{\mathbf{i},t}$ is the immigrant wage earned in Home, so that the emigrant labor income is $w_{\mathbf{i},t} L^s_{\mathbf{i},t}$. Also, $w^s_{\mathbf{u},t}$ is the wage earned in South, so that $w^s_{\mathbf{u},t} \left(L^s_{\mathbf{u},t} - L^s_{\mathbf{i},t} \right)$ denotes the total income from hours worked by the non-emigrant labor. On the spending side, each new unit of emigrant labor sent to Home requires a sunk cost f_e, expressed in units of immigrant labor: $f_{e,t} = \frac{w_{\mathbf{i},t}}{(\mathbb{X}_t \varepsilon^Z_t)} (\varepsilon^{fe}_t \mathbb{X}_t f_e)$. Changes in labor migration policies (i.e. border enforcement) are reflected by shocks ε^{fe}_t to the level of the sunk emigration cost f_e. Household consumption, C^s_t, is a CES composite of non-tradables produced in South, $C^s_{N,t}$, and the Home tradable composite $C^s_{T,t}$ which may account for immigrants' consumption in Home, as well as imports from Home

[23] Our endogenous emigration-exogenous return formulation is similar to the framework with firm entry and exit in Ghironi and Melitz (2005).

to South.[24] P^s_t is the resulting consumer price index.

Optimality Conditions The optimization problem delivers the typical conditions for consumption and labor supply. Using the law of motion for the stock of immigrant labor, the first order condition with respect to new emigrants $L^s_{\mathbf{e},t}$ implies:

$$f_{e,t} = \mathbb{E}_t \sum_{s=t+1}^{\infty} [\beta(1-\delta_l)]^{s-t} \left(\frac{\zeta^s_s}{\zeta^s_t}\right) (w_{\mathbf{i},t} - w^s_{\mathbf{u},t}). \tag{12}$$

In equilibrium, the sunk emigration cost, $f_{e,t}$, equals the benefit from emigration, with the latter given by the expected stream of future wage gains from working abroad (i.e. $w_{\mathbf{i},t} - w^s_{\mathbf{u},t}$) adjusted for the stochastic discount factor and the probability of return to the country of origin every period, δ_l.

Non-Tradable Sector Southern output is non-tradable and obtained as a linear function of non-emigrant labor: $Y^s_{N,t} = (\varepsilon^s_t \mathbb{X}_t)\left(L^s_{\mathbf{u},t} - L^s_{\mathbf{i},t}\right)$. Here, $\mathbb{X}_t$ is the unit-root global technology shock and ε^s_t is a country-specific shock. The price of the non-tradable good is: $P^s_{N,t} = \frac{w^s_{\mathbf{u},t}}{\mathbb{X}_t \varepsilon^s_t}$. By definition, $Y^s_{N,t} = C^s_{N,t}$.

2.4 Aggregate Accounting, Shocks, and Functional Forms

For simplicity, we define a consolidated current account for Home and South. Thus, the evolution of the net foreign asset position for this artificial economy is:

$$q_t B_t - B_{t-1} = N_{X,t} \left(\tilde{w}_{X,t}\right)^{1-\theta} N^*_t \mathrm{Q}_t - N^*_{X,t} \left(\tilde{w}^*_{X,t}\right)^{1-\theta} N_t, \tag{13}$$

where, on the right-hand side, the first term is the sum of all tasks executed by home skilled workers and exported to Foreign, and the second term represents the tasks executed by foreign skilled workers and imported in Home, expressed in units of the home numeraire. This trade in tasks is one of the key characteristics of this model. The Home and Foreign risk-free bonds are in zero net supply: $B_t + B^*_t = 0$.

[24]Since we consolidate the current account for Home and Foreign. We abstract from modelling migrants' remittances which, in principle, could be used to finance these imports.

The world technology shock has a unit root, as in Rabanal et al. (2011): $\log \mathbb{X}_t = \log \mathbb{X}_{t-1} + \eta_t^{\mathbb{X}}$. The other structural shocks in our model follow $AR(1)$ processes with i.i.d. normal error terms, $\log \varepsilon_t^{\hat{\imath}} = \rho^{\hat{\imath}} \log \varepsilon_{t-1} + \eta_t^{\hat{\imath}}$, in which the persistence parameter is $0 < \rho^{\hat{\imath}} < 1$. The error terms are $\eta \sim N(0, \sigma^{\hat{\imath}})$, and indexes $\hat{\imath} = \{\mathbb{X}, Z, Z^*, s, b, b^*, \tau, f_e, Tr\}$ denote the following shocks to: Global, Home, Foreign, and South technology, demand in Home and Foreign, iceberg offshoring cost, and sunk emigration cost, respectively. Country specific shocks are independent.

The baseline specification assumes perfect substitution between native and immigrant workers, so σ_N is set at an arbitrary very high value. This assumption is relaxed in Section 5, when we discuss the effect of complementarity between natives and immigrants. The idiosyncratic productivity of workers $\mathbf{z}$ follows a Pareto distribution $\mathcal{F}(\mathbf{z}) = 1 - \left(\frac{1}{\mathbf{z}}\right)^k$ suitable to match the skewed U.S. income distribution.[25]

[25]The shape parameter k is such that $k > \theta - 1$ so that $\mathbf{z}$ has a finite variance. When the parameter k is set at higher values, the dispersion of the productivity draws decreases and the idiosyncratic productivity becomes more concentrated toward the lower bound of the skill distribution.

3 Data and Estimation

The Bayesian estimation technique uses a general equilibrium approach that addresses the identification problems of reduced form models. It is a system-based analysis that fits the solved DSGE model to a vector of aggregate time series and combines priors and the likelihood function to obtain posterior distribution of the structural parameters. See the appendix for detailed information on data sources and the estimation methodology.[26]

Data The number of data series used in the estimation cannot exceed the number of shocks to avoid stochastic singularity. We use seven quarterly data series for the interval from 1983:Q1 to 2018:Q4 to estimate the model. We have data which is posterior to the years described. However, we choose not to use due to the presence of massive non-linearities in the postpandemic world, which our Bayesian estimation strategy cannot properly accommodate. These include the immediate collapse in employment and output prompted by lockdown measures, but also sharp reverse in immigration apprehensions in the last years. Nonetheless, we use the resulting estimated parameters here to analyze the welfare implications of these late events at the end of the paper.

For the estimation per se, we consider the following observables: First, we use U.S. real GDP as a proxy for Home GDP; Foreign GDP is constructed as a trade-weighted aggregate of the U.S. major trade partners; and Mexico's real GDP serves as a proxy for the South GDP. Second, the number of U.S. border patrol officer hours at the U.S./Mexico frontier serves as a proxy for the intensity of border enforcement. An increase in border patrol hours is interpreted as an increase in the sunk migration cost, as in Mandelman and Zlate (2012). Third, U.S. employment data is grouped in three skill groups (high-skill, middle-skill, and low-skill occupations). Fourth, real tuition costs is defined as tuition, other School Fees, and childcare as jointly measured by the Bureau of Labor Statistics, deflated by the total consumer price index (CPI). For robustness, we allow for this measure not to be necessarily linked to total training costs

[26]In addition, the appendix includes a description of the smoothing procedure implemented with the Kalman filter, the Monte Carlo Markov Chain (MCMC) convergence diagnostics, and the Bayes Factor used for model comparison.

in a linear fashion. That is, we let the data to pin down the value of the elasticity defined in the model description. All series are seasonally adjusted and expressed in log-differences to obtain growth rates.[27] The U.S. Census employment data discussed in the introduction is decennial and thus not available on a high-frequency basis. In addition, it cannot be split easily into the three skill groups. Therefore, we follow a similar approach to Acemoglu and Autor (2011) and Jaimovich and Siu (2020) and construct employment by skill group using data from the Current Population Survey (CPS). We consider three categories of employment based on the skill content of the tasks executed by each occupation in the Census data: Non-Routine Cognitive (high-skill), Routine Cognitive (middle-skill) and Non-Routine Manual (low-skill). An occupation is regarded as routine if it involves a set of specific tasks that are accomplished by executing well-defined instructions and procedures. On the contrary, it is categorized as non-routine if it requires flexibility, problem-solving, or interpersonal skills. In addition, among the non-routine occupations, the distinction between cognitive and manual is given by the extent of mental versus physical activity. Following these criteria, first, the non-routine cognitive occupations include managers, computer programmers, professionals, and technicians, and are located at the top of the skill distribution. Second, the routine occupations include blue collar jobs such as machine operators, assemblers, data entry, help desk, and administrative support, and are located in the middle of the skill distribution. Third, the non-routine manual occupations are mostly service and construction jobs, which are typically found at the bottom of the skill distribution. Service occupations are jobs that involve assisting and caring for others, and involve tasks that must be executed where the final consumer is located. Notice, that in the estimation we use total employment over population (16 years or older) for each skill group while the introduction illustrates changes in employment shares in the Census data.[28]

Two important covariates are not used in the model estimation. These include (a) the inflows of

[27] The GDP and employment variables are not detrended, but border enforcement is detrended with a linear trend. In the balanced-growth path, border enforcement is supposed to grow at the same rate than output. To render this last variable stationary, we follow Adolfson et al. (2007) and remove the excessive trend in border enforcement with a linear trend.

[28] In Jaimovich and Siu (2012) construction occupations are grouped with the middle-skill segment. We take a different approach for two reasons. First, construction is non-tradable by definition. Second, even though the earnings for the registered workers belong to the middle of the skill distribution. The underground economy is pervasive in this sector, and most low-skilled laborers in this sector remain unregisted. See the data appendix for more details.

low-skill migrant workers and (b) the cost of offshoring. These variables do not enter the estimation for different reasons. A large number of low-skill migrants arrive illegally and remain undocumented, hence it can only be regarded as an accurate but a noisy proxy for these flows when measured at short-run frequencies. Also, the cost of offshoring is affected not only for changes in trade costs, but also for advances in telecommunications. These advances facilitate breaking down the production process in different locations as they allow workers in distant places to interact and monitor each other in real time. It is not feasible, however, to directly quantify the impact of these technological advancements in the actual cost of offshoring tasks. In sum, we construct two series that serve as alternative proxies for these two unobserved variables. These proxies are not directly considered in the model estimation. However, as described below, they will be use to evaluate the empirical adequacy of the model predictions.

The number of individuals being arrested (apprehended) by the U.S. patrol officers when attempting to illegally cross the U.S./Mexico border serves as a proxy for the inflow of low-skill migrant workers. As pointed out in Hanson and Spilimbergo (1999), apprehensions are undoubtedly correlated with the flows of attempted illegal immigration. Nonetheless, they represent an imperfect indicator for such flows due to their complex relation with the intensity of border enforcement. Higher enforcement may discourage attempted illegal immigration but, for a given number of crossing attempts, higher enforcement can also result in more arrests. To address this issue, Hanson and Spilimbergo (1999) use instrumental variables methods to account for illegal immigration inflows, which result in the following reduced form specification: $\ln(\text{Apprehensions})-0.8\times\ln(\text{OfficerHours})$. We mimic their approach and use this measure as a proxy for migration flows.

As explained above, one sizable component of the iceberg offshoring costs is the actual cost of international trade that can actually be measured in the data. Hence, as a proxy for offshoring costs, we use an index that measures the wedge between the CIF and FOB import prices, where the former includes freight and insurance for the goods in transit while the latter is free on board at the suppliers' shipping dock. This indicator obtained from the U.S. International Trade Commission is one of the most accurate and widely used measure of shipping costs in the literature.[29] Other observables not used in the estimation but for model validation are private consumption, net exports, and the trade-weighted real exchange rate (all for the U.S.).

Calibration and Prior distributions We calibrate six key parameters affecting offshoring and labor migration so that model stationary variables match six sample averages from the data. Specifically, (1) The ratio of non-routine cognitive (high-skill) to routine (middle-skill) jobs in the U.S. is 0.54. (2) The ratio between the high- and middle-skill labor income shares in the total U.S. labor income is 1.6.[30] (3) The share of routine manual (low-skilled) workers in the native U.S. labor force is 0.2 (4) The ratio between U.S. (Home) low-skill wages and wages in Mexico (South) is 1.9.[31] (5) The ratio of U.S. exports to GDP is 0.13. (6) The ratio of U.S.-to-Mexico per-capita nominal GDP is 5.5. To match these six stationary targets, we set the sunk emigration cost at $f_e = 8.8$ and the quarterly return rate of immigrant labor at $\delta_l = 0.05$, which is consistent with the data in Reyes (1997).[32] The iceberg trade cost is $\tau = \tau^* = 1.40$, consistent with Novy (2006), and the fixed cost of offshoring is $f_o = f_o^* = 0.0155$. The Pareto shape parameter is $k = 3.1$, and the elasticity of substitution across tasks in Home and Foreign is $\theta = 2.4$. The prior distribution for the elasticity of total training to costs to observed tution costs, Θ, is centered at 0.35.

Other parameters are calibrated using standard choices from the literature.[33] Some of these para-

[29] We thank Pierre-Louis Vezina for sharing this dataset.

[30] We use the Current Population Survey (CPS) from the Census Bureau. The survey reports a "money income" that includes wages and salaries, interest, dividends, rent, retirement income as well as other transfers. There is one important caveat. Our basic model abstracts from capital, so it is difficult map each of these income sources to the skill groups defined in our setup. In addition, the CPS survey data is not suitable to study high income groups because of small sample size and top coding of high incomes.

[31] BLS and INEGI are the data sources, for the U.S. and Mexico, respectively. For the U.S., we consider median labor earning for males with less than a high-school degree. For Mexico, we take the median wage for males.

[32] Reyes (1997) studies the return pattern of undocumented Mexican immigrants. She finds that approximately only 50% remain in the U.S. after 2 years. Similarly, 35%, 25%, and 20%, of them remain after, 4, 10, and 15 years, respectively. We construct quarterly return rates based on these numbers. The resulting average is 0.05.

[33] These include the discount factor, $\beta = 0.99$, and the inverse of the elasticity of intertemporal substitution, $\gamma = 2$. The cost of adjusting bond holdings is set at a very low value, $\phi = 0.0035$, which is sufficient to ensure stationarity. For labor supply, γ_n is set at 1.33, so that the Frisch elasticity $(1/\gamma_n)$ is consistent with the micro estimates in Chetty et al. (2012). The weights on the disutility from work are $a_n = 3.9$ in Home and Foreign and $a_n^s = 8.6$ in the South, so that per-capita labor supply is normalized in balanced-growth ($L_t = L_t^* = L_{\mathbf{u},t}^s = 0.5$). The share of tradable consumption is $\gamma_c = 0.75$ and the intra-temporal elasticity of substitution between the tradable goods and services is set at a relatively low value of $\rho_c = 0.44$ as in Stockman and Tesar (1995). The quarterly job destruction rate is set at $\delta = 0.025$ as in Davis and Haltinwanger (1990). In the South, the share of the Home-produced tradable good γ_c^s in Household consumption is 0.2, the associated elasticity of substitution is $\rho_c^s = 1.5$. The sunk training cost is normalized to $f_j = 1$. Notice, however, that the interpretation for some of these parameters is different in the cited literature. There are no tradable *goods* but tradable *tasks* in this framework. In addition, job destruction is associated

meter values remain fixed through the estimation procedure, which can be interpreted as a prior that is extremely precise. This is required to address identification issues arising from the limited number of variables used in the estimation. We estimate a key set of parameters depicted in Table 1.[34] The prior probability density functions are centered at the values described above and display a standard deviation that delivers a domain suitable to cover a wide range of empirically plausible parameter values. Shocks are harmonized with a very loose prior since we do not have much prior information about their actual magnitude.

Estimation Results (Posterior Distributions) The last four columns of Table 1 report the posterior mean, mode, as well as the 10th and 90th percentiles of the posterior distribution of the parameters.[35] The estimated sunk emigration cost f_e , and the sensitivity of training costs to the increase in observed tuition costs are substantially lower than its prior. The posterior mean value indicates that the sunk cost per unit of emigrant labor is equivalent to the immigrant labor income obtained over seven quarters in the destination economy. This value is only slightly higher than the estimate of five quarters found in Mandelman and Zlate (2012), which was based on a shorter time series for border enforcement (1983-2004). Iceberg offshoring costs faced by Home are significantly higher than for Foreign. This might be interpreted as the U.S. specializing on tasks requiring more on-site interactions while foreign countries providing tasks that are relative more routine-intensive and easier to monitor remotely (see, for instance, Antràs et al. 2006). Technology shocks are relatively more persistent than demand shocks, which is in line with our priors and consistent with the literature (e.g. Smets and Wouters 2007). Offshoring costs are very persistent but relatively less volatile; in contrast, the shock to border enforcement is slightly less persistent but notably more volatile. Consistent with the evidence discussed below, the increase in real tuition costs are highly persistent (near unit-root).

with skills becoming obsolete in here.

[34]These include: f_e, τ, τ^*, γ_n, a_n, γ_n^s, and a_n^s as well as the stochastic process for all the shocks described earlier. Model parameters are assumed to follow a `Gamma` distribution with a possitive domain $[0,\infty)$. The autoregressive parameters for the stationary shocks are assumed to follow a `Beta` distribution, which covers the range between 0 and 1. The standard deviation of all stochastic processes are assumed to follow an `InverseGamma` distribution that delivers a relatively large domain.

[35]Prior and posterior densities are graphed in the appendix. The posterior mode for the vector of parameters $\{f_e, \tau, \tau^*, \gamma_n, a_n, \gamma_n^s, a_n^s\}$ is $\{7.12, 1, 43, 1.35, 1.17, 4.14, 1.19, 8.59\}$.

4 Model Fit and the Effect of Shocks

4.1 Model Fit

We proceed with a brief posterior predictive analysis where the actual data are compared with artificial times series generated with the estimated model. As discussed before, we do not use data series on immigrant flows or offshoring costs to estimate the model. Instead, we treat immigrant entry ($L_{e,t}$) and the iceberg offshoring cost (τ_t) as latent variables in the estimated model and compare them with data proxies to assess the model fit. For this purpose, the Kalman filter backs out smoothed estimated shocks to deliver predictions for unobserved variables every period, which allows for the reconstruction of the artificial historical series. [36]

Fig. 6A shows model predictions for the flows of low-skilled immigrant labor expressed as deviations from balanced-growth (thick lines) along with their empirical detrended proxy for migration (thin lines). The model predictions are largely consistent with the data. The model prediction for immigrant entry follows the data closely for most of the sample. Notably, the model matches the increase in adjusted border apprehensions (arrests) during the early-1990s, the increase during the early-2000s (which coincided with the U.S. housing and construction boom), as well as their sharp drop during the 2008 crisis, and the posterior stabilization at the very end of the sample.

In panel B, the model prediction for the iceberg offshoring cost matches well the CIF-to-FOB USITC indicator for the period before 2008, in both historical pattern and magnitude. During and after the 2008 crisis, the model predicts an increase in trade costs while the data show a decline. This apparent discrepancy may be reconciled with additional information not captured by the ITC indicator, which does not account for factors such as the increase in trade protectionism during the crisis reflected in the increase in non-tariff barriers (see Georgiades and Gräb, 2013), and the freeze in trade credit (i.e., financing from international suppliers in the form of delayed payments for shipped goods, see Coulibaly et al., 2011),

[36]See the appendix for details on the smoothing procedure. One-sided estimates of the observed variables deliver a satisfactory in-sample fit. Results available upon request.

all of which contributed to the trade collapse during the 2008 crisis. The decrease in the ITC indicator likely reflects the excess capacity in the shipping industry and the decrease in oil prices during the crisis. Taking all together, the model predictions for the evolution of low-skilled immigration and offshoring costs appear largely consistent with the data. This result is remarkable, given that we do not use data series on labor migration or trade flows to estimate the model.

4.2 Impulse Response Functions

In what follows, we describe the model's transmission mechanism in response to a decline in migration, training, and offshoring costs. We also assess the impact of innovations to labor productivity. We postpone to the appendix the characterization of the remaining shocks.

Decline in the sunk migration costs Fig. 7 shows the estimated median impulse responses (along the 10% and 90% posterior intervals) of key model variables to a negative shock to a decline in migration costs (one standard deviation), expressed as percentage deviation from balanced growth. This reflects the effect of a decrease in the barriers to low-skilled immigration. Immigration inflows rise on impact, and but the stock of immigrant labor only rises gradually over time. The native household reacts by investing in training, and reallocating labor away from low-skill service occupations and toward high- and middle-skill occupations (mimicking the task upgrading in Ottaviano et al., 2013). As a result, native low-skill employment declines while the number of high- and middle-skill jobs rises slowly over time. The downward pressure of low-skilled immigration on lowed-skill wages– along with the shift in native employment toward high- and middle-skill occupations – leads to an increase in the income shares of high- and middle-skill workers, but to a decline in the income share of low-skill ones. The skill premium grows as result. In sum, immigration incentivizes the acquisition of skills, and boost labor productivity and income of the trained workers.

Increase in training costs

Fig. 8 shows the impulse response to an increase in training costs. Due to the higher costs, more workers choose to remain untrained boosting the supply of low-skill labor on impact. This put downward pressure on wages, but also on the price of non-tradable services. This induces a decline on immigration falls and, over time, the stock of immigrants decline. These explains why at longer horizons the aggregate supply of low-skill labor becomes negative. Low skill wages remain low, however. At longer horizons, the persistent decrease in training, eventually dents into total labor productivity, lowering real wages. This may be interpreted as a Harrod-Balassa-Samuelson effect, in which lower productivity leads to lower non-tradable prices and a real exchange rate (RER) depreciation. RER adjustments explain why in the margin there is some increase in High-Skill employment. Native skilled workers become more competitive in the global marketplace, which ultimately allows for some upskilling among the most productive (high **z**) middle-skill workers.

Decline in offshoring costs This shock displayed in Fig. 9 is symmetric across countries. Only the variables for Home are displayed, however. Easier offshoring induces multinationals to expand the number of tasks executed abroad. This boosts the employment of high-skill workers that execute tasks for the global market, but displaces middle-skilled workers who face lower earnings resulting from the competition of offshore workers. Efficiency gains from task specialization arise, which enhance the aggregate labor productivity. As aggregate income increases, so do the demand for non-tradable services and low-skill employment (see the top row). Thus, the model generates polarization of the labor market. Workers at the upper and lower tails of the skill distribution not only enjoy better employment outcomes, but also gain a higher share of income at the expense of those situated in the middle of distribution (see the bottom row). In turn, the initial increase in low-skill wages induce southern households to send more migrants to Home (middle row). As the stock of immigrants builds up, the increase in low-skill wages and their associated share of income is tempered (with respect to a counterfactual without immigration).[37] Notice that immigrant and native low skill wages are identical under the assumption of perfect substitution.

Productivity shocks

[37]These results are not displayed here, but are available upon request. Consistent with Mishra (2007), immigration instead results in wage gains in the migrants' country of origin as labor supply declines there.

A transitory technological innovation in the tradable sector is displayed in Fig.10. This shock resembles a skill-biased technological change–since productivity grows steadily in the tradable sector that employs skilled labor inputs. Consequently, the return to job creation in the middle to-high skill segment increases, and households react by devoting more resources to training. The substitution effect dictates that consumption demand should move away from the non-tradable service sector towards the tradable sector since this last sector benefits from lower effective costs arising from the productivity gains. However, the income effect clearly dominates. That is, higher productivity and aggregate income boost the demand for non-tradable services and low-skill employment. In turn, this attracts more immigration with the effects discussed above.

4.3 Historical decomposition

Figs. 11-13 show the historical contribution of the estimated shocks to key model variables during the period 1983:Q2-2018:Q4. These variables include employment and income shares for each skill group, as well as labor migration related indicators. Variables (expressed as positive or negative deviations from balanced-growth in the vertical axis) are depicted with a tick black line. The historical contributions of shocks to the evolution of each variable is represented by the colored bars. Employment for each skill group and U.S./Mexico, border enforcement, and training costs reflect the actual data used in the estimation. Border enforcement is exogenous in our model and we entirely link it to an increase in migration cost shocks (dark red bars). Same applies to training costs (solid green bars). Several large swings in border enforcement policy appear to be associated with the U.S. political cycle. The Immigration Reform and Control Act of 1986 provided amnesty for some of the workers that arrived prior to 1982, but also involved increase in border enforcement that nonetheless was very short-lived. Overall the first half of the sample 1983-1996, shows a sustained relaxation in migration barriers that is associated with large increase in migration flows. The Illegal Immigration Reform Act under the Clinton Administration in 1996 was also accompanied by tightened enforcement, which this time showed to be more persistent. Border enforcement tighten further during the Great Recession, and only showed some relaxation by the end of the sample. As we discussed later, the last year of the sample deserves some caution however. Fundamental changes in the treatment of undocumented implemented during the Trump administration (e.g., longer detention periods, family separations, and end of *catch and release* protocols) may have broken the statistical link between apprehensions and immigration. In turn, training costs display a steady upward trend in tuition costs that persists through the sample period used for the estimation (see Fig 1b).

Accounting for historical events Consistent with the microeconomic evidence in Firpo et al. (2011), the historical decomposition indicates that technological change (dashed purple bars) played a central role to explain the increase in inequality among these groups in the 1980s, while the declining cost of offshoring (light blue bars) became a dominating factor benefiting high-skill occupations at the expense of middle-skill ones from the 1990s onwards. Similar to Jaimovich and Siu (2020), technology shocks dampened middle-skill employment during the three recorded recessions (1990-91, 2001, and 2007-09). In turn, the decrease in migration costs contributed positively to the growth in both high- and middle-skill employment during the late-1980s and the 1990s, as immigration prompted native low-skill workers to undergo training and task upgrading. The increase in tuition costs was detrimental to skill upgrading, contributing to a decline overall skilled workers. Due to the Harrod-Balassa-Samuelson effect explained above, lower labor productivity is associated with gains in international competitiveness which allows the most-productive skilled workers to engage in offshore production. Refer to Fig 11A-B.

Fig. 11C shows the evolution aggregate low-skilled employment. The decline in offshoring costs and immigration barriers made positive net contributions to aggregate low-skill employment during the 1990s. The relative small effect of the decline in immigration costs to this variable conceals sizable composition effects between natives and immigrants. As shown in Fig. 13 (B and C), a remarkable decline in native low-skilled employment coincided with a steady increase in immigration flows. Notice that shocks to training and migration costs have the opposite contributions. Quantitatively, the increase in the supply of low-skilled natives due to higher tuition costs is more than offset by the larger decline in immigration, resulting in negative contributions to aggregate low-skill employment at the end of the sample.

The sizable increase in aggregate low-skill employment in the early 2000s was driven by both an increase in productivity and consumption demand shocks (dotted green bars) linked to the housing boom. Conversely, the reversal of these transitory shocks explains the decline in low-skill employment in the aftermath of the Great Recession. The intuition for these demand shocks, displayed in the appendix, is as follows: Due to complementarity in consumption, a demand shock enhances the demand for both non-tradable and tradable consumption in Home. As a result, Home relies on Foreign to provide more of the tradable tasks (leading to an increasing trade deficit) and instead devotes more of its labor to produce non-tradables (which cannot be substituted with imports from Foreign). These consumer demand shocks may capture, in a reduced form, the financial innovations which potentially triggered a boom in consumption and residential construction in the early 2000s, with the subsequent reversal during the crisis. In addition, negative demand shocks in Foreign may capture the increasing supply of foreign savings documented during those years (i.e. the global savings glut) not modelled here.[38] Of note, the boom-bust in low-skill (non-tradable) employment coincided with a sizable increase in the U.S. current account deficit, with a subsequent remarkable correction after the crisis.[39]

Finally, immigrant entry was driven by a sustained declined in migration barriers in the 1980s. This policy stance, which was only briefly interrupted with the 1986 immigration reform, lasted until the mid-1990s. The 1996 reform initiated a persistent increase in enforcement that turned the migration tide thereafter. This negative trend in immigration was temporarily interrupted with a brief expansion during the economic boom of the early 2000s (which also coincided with a brief relaxation in migration barriers), but resumed at the onset of the Great Recession. The immigration slump persisted until the end of the sample, contributing to the overall shortage of low skill workers motivating our analysis.

5 Welfare Implications (To be Completed)

Fig. 8 shows the welfare outcomes from counterfactual scenarios depicting a change in either immigration (Panels A and D) or trade policy (Panels B and E) for Home. For this purpose, sunk migration costs or the iceberg offshoring costs faced by Home are lowered or increased from their estimated median values ($f_e = 7.13$ and $\tau = 1.41$) on the horizontal axis. Resulting welfare gains (or losses) from these policy changes are depicted on the vertical axis. Welfare gains (losses) are obtained as the percent of the expected stream of consumption that one should add (or subtract) to the estimated benchmark model so that the representative household of each country would be just as well-off as in each of the counterfactual scenarios considered. Notice that the representative household in Home only accounts for the native

[38] See Kehoe et al. (2016) for more details.

[39] The current account deficit fell from 6.2% of GDP in 2006:3 to 2.5% in 2009:2.

workers while the Southern household accounts for the welfare of migrant workers.[40] Results are based on a second-order approximation around the balanced growth path.

In panels A and B we shut down all the estimated shocks to evaluate the welfare implications in the stationary equilibrium. Lowering the barriers to immigration has a positive impact on aggregate welfare in both the Home and South, while providing marginal gains also for Foreign. In Home, the reduction in migration barriers depresses wages for the native low-skilled workers, but also lowers the price of non-tradable services and encourages training and task upgrading, which overall have a positive effect on home welfare once we abstract from distributional issues. For South, the decrease in migration barriers (costs) allows the Southern' household to send more of their workers to the location with higher wages.

Panels D and E include all the estimated shock processes in the analysis. This alternative approach allows us to account for the welfare effects of transitory and permanent shocks altering the model dynamics under different policy scenarios. Notably, the welfare gains that South obtains from lower migration barriers are higher in the presence of shocks. The result highlights the role of labor migration as an insurance mechanism for the Southern household, who can send more migrants when South is hit by negative productivity shocks or, conversely, when Home enjoys positive shocks. For Home, the opposite takes place, as their welfare gains are significantly smaller when compared to those in the stationary scenario. Namely, native workers have to share with foreigners the benefits of shocks that increase labor income and cannot migrate if the opposite takes place.[41]

The reduction in the iceberg offshoring costs faced by Home is welfare-improving for all the three economies. Home can specialize in its most productive tasks while Foreign benefits from the increasing availability of complementary Home tasks, that also enhance specialization. The price (wage) impact on the terms-of-trade (labor) resulting from increasing availability of Home tasks in Foreign explain why the gains are relatively bigger for Foreign. In addition, some of the Homes's welfare gains are also transferred

[40] Implicitly, we assume that migrants in Home use remittances to transfer funds to their country of origin to equalize utility across household members in different locations (see Mandelman and Zlate, 2012, for details). Remittances are netted out in the consolidated current account for Home and South.

[41] Cho et al. (2015) shows that when productivity shocks are multiplicative and labor inputs are variable (as in our model) an economy may enjoy higher welfare in the presence of transitory technology shocks which allows households to "make hay while the sun shines."

to South, through the income of immigrant workers.

Complementarity between Native and Foreign labor The welfare gains that Home obtains from lower migration barriers constitutes a lower bound in the extreme case with perfect substitution between the native and immigrant low-skill workers, which is featured in the baseline model parameterization. Fig. 8 (panels C and F) shows the impact on welfare gains when the elasticity σ_N is lowered to values that imply less than perfect substitution (i.e. from $\sigma_N \to \infty$ to $\sigma_N \to 0$).

With increasing complementarity, a decrease in migration barriers provides even greater gains to the Home economy, as immigrants complement rather than substitute low-skill native workers. For South, welfare gains become relatively lower since two offsetting forces are at work: Higher migration barriers lower the number of immigrants; however, when immigrant labor is scarce it receives a higher wage if needed to complement the more plentiful native labor. Notably, for most values of this elasticity parameter, both economies would benefit from lower migration barriers. Model estimation results for alternative model specifications in which we allow for different values of this elasticity, σ_N, are in the appendix.[42]

6 Conclusion

This paper develops and estimates a three-country stochastic growth model with skill heterogeneity, automation, offshoring and low-skill immigration. The model generates four key implications. First, offshoring leads to employment polarization. As automation and offshoring costs decline, trade in tasks benefits high-skill occupations. Task specialization increases productivity and aggregate income, enhancing the demand for non-tradable service occupations provided by low-skill workers. Second, immigration supports employment in this service sector but dampens low-skill wages. Low-skilled immigration encourages skill upgrading by native workers. Decreasing the barriers to low-skilled immigration improves welfare by lowering the price of services, by encouraging native workers to train, and by enhancing pro-

[42] The marginal likelihood principle (Bayes Factor) indicates that general fit to the data of each specification is similar, with a slight preference to our baseline with perfect substitution. The elasticity $\sigma_{N,}$ cannot be properly identified in the data since we do not count with disaggregated (native/foreign) high frequency employment and wage data for the three skill groups considered.

ductivity as the economy specializes in tasks in which is more efficient.

The stochastic growth model in this paper is suitable to analyze short- to medium-run business cycle dynamics in addition to long-term developments. Low-skilled immigration accelerated when migration barriers declined during the 1980s and initiatated a steady slowdown with the increase in border enforcement that began with the 1996 U.S. immigration reform. The robust housing boom in the early 2000's overshadowed this tighter border enforcement sustaining these migration flows. After that, the immigration tide was reversed and initiated a sustained slump following a succession of shock. Namely, the Great Recession and the slow employment recovery (which hit construction and consume demand particularly hard), and later Trump's administration enhanced immigration restrictions (e.g., end of catch and release, longer detention time, and family separations).

During the pandemic, the most acute labor shortages and higher wage growth were precisely in occupations at the bottom of the skill distribution (including food service & hospitality workers, child care providers, home health aides), as well as, construction laborers. At first, the shortages were associated with the fact that these jobs required person-to-person interactions with final consumers and therefore could not be performed remotely. However, this same characteristic explains why immigrants leaned to fill these jobs on the first place, as they could not be offshored or automated. These shortages remained after the pandemic effects waned–amid widespread vaccination– signalling a more important role for the structural factors described here. Indeed, in our empirical work, we can link these labor shortages to the decline in the skill premium. Noticeably, the decrease in the skill premium is associated with lower tuition costs. Spikes in consumer demand, like those associated with the several round of stimulus that started with the CARES Act result in remarkable welfare losses amid much higher consumer prices. This is explained by the shortage of immigrants, that are hard to substitute with imports (offshoring) or automated capital.

While our model setup is sufficiently rich for a quantitative analysis, we have abstracted from one crucial feature: demographic changes. Declines in fertility rates throughout Latin America have likely contributed to the recent slowdown in low-skilled immigration. Declines in fertility in the U.S. makes more costly to replace them, We leave these important issues for future research.

References

[1] **Acemoglu, D., Autor, D., 2011.** Skills, Tasks and Technologies: Implications for Employment and Earnings. in O. Ashenfelter and D. Card, eds. Handbook of Labor Economics, vol. 4.

[2] **Adolfson, M., Laseén, S., Lindé, J., Villani, M., 2007.** Bayesian estimation of an Open Economy DSGE model with incomplete pass-through. *Journal of International Economics*, 72(2): 481–511.

[3] **Andolfatto, D., 1996.** Business Cycles and Labor Market Search. *American Economic Review,* 86(1): 112–132.

[4] **Antràs, P., Garicano L., Rossi-Hansberg E., 2006**. Offshoring in a Knowledge Economy. *Quarterly Journal of Economics*, 121(1): 31–77.

[5] **Autor, D., Dorn, D., 2013.** The Growth of Low Skill Service Jobs and the Polarization of the U.S. Labor Market. *American Economic Review*, 103(5): 1553–1597.

[6] **Borjas, G., Grogger, J., Hanson, G., 2008.** Imperfect Substitution between Immigrants and Natives: a reappraisal. NBER WP 13887.

[7] **Burstein, A., Vogel, J., 2016.** International Trade, Technology and the Skill Premium. *Journal of Political Economy,* forthcoming.

[8] **Chetty, R., Guren, A., Manoli, D., Weber, A., 2012.** Does Indivisible Labor Explain the Difference Between Micro and Macro Elasticities? A Meta-analysis of Extensive Margin Elasticities. *NBER Macroeconomics Annual* 2012, 27.

[9] **Cho, J., Cooley, T., Kim, H., 2015.** Business Cycle Uncertainty and Economic Welfare. *Review of Economic Dynamics*, 18: 185–200.

[10] **Cortes, P., 2008.** The Effect of Low-Skilled Immigration on U.S. Prices: Evidence from CPI Data. *Journal of Political Economy*, 116(3): 381–422.

[11] **Coulibaly, B., Sapriza, H., Zlate, A., 2011.** Financial Frictions, Trade Credit, and the 2008–09 Global Financial Crisis. *International Review of Economics and Finance*, 26: 25–38.

[12] **Crinò, R., 2010.** Service Offshoring and White-Collar Employment. *Review of Economic Studies*, 77(2): 595–632.

[13] **Davis, S., Haltiwanger, J., 1990.** Gross Job Creation and Destruction: Microeconomic Evidence and Macroeconomic Implications. NBER Macroeconomics Annual, 5: 123–186

[14] **di Giovanni, J., Levchenko, A., Ortega, F., 2015.** A Global view of Cross-Border Migration. *Journal of the European Economic Association*, 13(1): 168–202

[15] **Firpo, S., Fortin, N., Lemieux, T., 2011.** Occupational Tasks and Changes in the Wage Structure. IZA Discussion Papers 5542.

[16] **Friedberg, R., Hunt, J., 1995.** The Impact of Immigrants on Host Country Wages, Employment and Growth. *Journal of Economic Perspectives*, 9(2): 23–44.

[17] **Georgiadis, G., Gräb, J., 2013.** Growth, Real Exchange Rates and Trade Protectionism Since the Financial Crisis, WP 1618, ECB.

[18] **Ghironi, F., Melitz, M., 2005**. International Trade and Macroeconomic Dynamics with Heterogeneous Firms. *Quarterly Journal of Economics*, 120(3): 865–915.

[19] **Goldberg, P., Pavcnik, N., 2007.** Distributional Effects of Globalization in Developing Countries. *Journal of Economic Literature*, 45: 39–82.

[20] **Grogger, J., Hanson, G., 2011.** Income Maximization and the Selection and Sorting of International Migrants. *Journal of Development Economics*, 95(1): 42–57.

[21] **Grossman, G., Rossi-Hansberg, E., 2008.** Trading Tasks: A Simple Theory of Offshoring. *American Economic Review*, 98(5): 1978–1997.

[22] **Grossman, G., Rossi-Hansberg, E., 2012.** Task Trade between Similar Countries: A Simple Theory of Offshoring. *Econometrica*, 80(2): 593–629.

[23] **Hanson, G., Spilimbergo, A., 1999.** Illegal Immigration, Border Enforcement, and Relative Wages: Evidence from Apprehensions at the U.S.-Mexico Border. *American Economic Review*, 89(5): 1337–1357.

[24] **Heathcote, J., Perri, F., 2002.** Financial Autarky and International Real Business Cycles. *Journal of Monetary Economics*, 49(3): 601–627.

[25] **Hunt, J., 2012.** The Impact of Immigration on the Educational Attainment of Natives. NBER WP 18047.

[26] **Itskhoki, O., 2008.** Optimal Redistribution in an Open Economy, mimeo. Princeton University.

[27] **Jackson, O., 2015.** Does Immigration Crowd Natives Into or Out of Higher Education? FRB Boston WP 15–18.

[28] **Jaimovich, N., Siu, H., 2012.** The Trend Is the Cycle: Job Polarization and Jobless Recoveries. NBER WP 18334.

[29] **Kehoe, T., Ruhl, K., Steinberg, J., 2016.** Global Imbalances and Structural Change in the United States. *Journal of Political Economy*, forthcoming.

[30] **Kennan, J., 2013**. Open Borders. *Review of Economic Dynamics* 16, 1–13.

[31] **Klein, P., Ventura, G., 2009.** Productivity Differences and the Dynamic Effects of Labor Movements. *Journal of Monetary Economics*, 56(8): 1059–1073.

[32] **Krishna, P., Poole, J., Senses, M. 2014.** Wage Effects of Trade Reform with Endogenous Worker Mobility. *Journal of International Economics*, 93(2): 239–252.

[33] **Mandelman, F., 2016.** Labor Market Polarization and International Macroeconomic Dynamics. *Journal of Monetary Economics*, 79: 1–16.

[34] **Mandelman, F., Zlate, A. 2012.** Immigration, Remittances and Business Cycles. *Journal of Monetary Economics*, 59: 196–213.

[35] **Melitz, M., 2003.** The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica*, 71(6): 1695–1725.

[36] **Mishra, P., 2007.** Emigration and Wages in Source Countries: Evidence from Mexico. *Journal of Development Economics*, 82: 180–199.

[37] **Novy, D., 2006.** Is the Iceberg Melting Less Quickly? International Trade Costs After World War II. Warwick Economic Research Paper 764.

[38] **Ottaviano, G., Peri, G., Wright, G., 2013.** Immigration, Offshoring and American Jobs. *American Economic Review*, 103(5): 1925–1959.

[39] **Ottaviano, G., Peri, G., 2012.** Rethinking the Effects of Immigration on Wages. *Journal of the European Economic Association*, 10(1):152–197.

[40] **Peri, G., Sparber, C., 2009.** Task Specialization, Immigration, and Wages. *American Economic Journal: Applied Economics*, 1(3): 135–69.

[41] **Rabanal, P., Rubio-Ramírez, J., Tuesta, V., 2011.** Cointegrated TFP processes and international business cycles. *Journal of Monetary Economics*, 58(2): 156–171.

[42] **Reyes, B., 1997.** Dynamics of Integration: Return Migration to Western Mexico. Research Brief, Issue 4, Public Policy Institute of California.

[43] **Rudebusch, G., Swanson, E., 2012.** The Bond Premium in a DSGE Model with Long-Run Real and Nominal Risks. *American Economic Journal: Macroeconomics*, 4(1): 105–143.

[44] **Smets, F., Wouters, R., 2007.** Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach. *American Economic Review*, 97(3): 586–606.

[45] **Stockman, A., Tesar, L., 1995**. Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements. *American Economic Review*, 85(1): 168–85.

[46] **Wright, G., 2014.** Revisiting the employment impact of offshoring. *European Economic Review*, 66: 63-83.

[47] **Zlate, A., 2016.** Offshore Production and Business Cycle Dynamics with Heterogeneous Firms. *Journal of International Economics*, 100: 34-49.

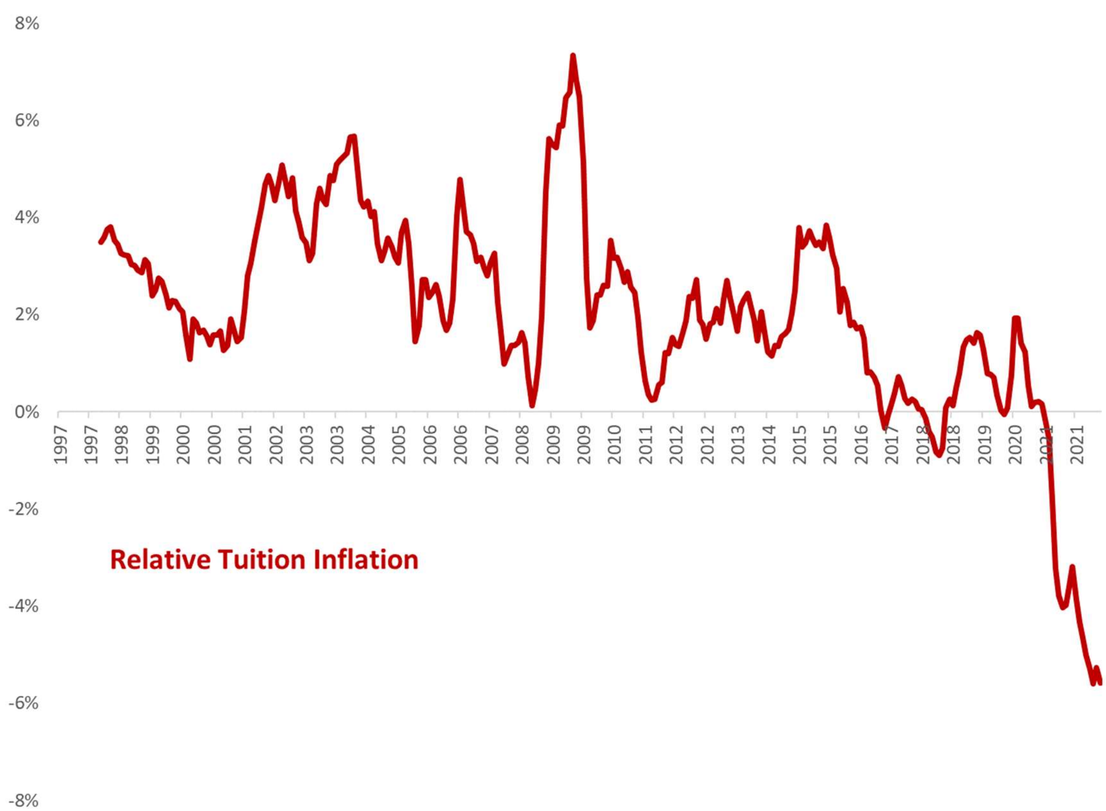
Table 1: Prior and posterior distributions of estimated parameters

	Prior distribution				Posterior distribution			
Description	Name	Density	Mean	Std Dev	Mode	Mean	10%	90%
Training sunk cost	f_{TR}	Beta	0.35	0.05	0.1927	0.1979	0.1639	0.2341
Migration sunk cost	f_{MIG}	Gamma	8.8	0.1	7.2320	7.3579	6.4824	8.2679
Trade iceberg cost (H)	τ	Gamma	1.40	0.15	1.4141	1.3920	1.2399	1.5521
Trade iceberg cost (F)	τ^*	Gamma	1.40	0.15	1.4816	1.5014	1.3786	1.6268
Inv. Elast. Labor Supp (H)	γ_n	Gamma	1.33	0.3	1.0768	1.1997	0.9604	1.4838
Weight leisure (H)	a_n	Gamma	3.90	0.3	4.0379	4.0037	3.6298	4.3699
Inv. Elast. Labor Supp (S)	γ_n^s	Gamma	1.33	0.3	1.0634	1.1439	0.8200	1.4873
Weight leisure (S)	a_n^s	Gamma	8.6	1	8.5748	8.6473	7.4334	9.8875
Training cost shock	ρ_{fTR}	Beta	0.75	0.1	0.9988	0.9983	0.9974	0.9990
Migration cost shock	ρ_{fMIG}	Beta	0.75	0.1	0.9802	0.9786	0.9676	0.9885
Trade cost shock	ρ_τ	Beta	0.75	0.1	0.9918	0.9894	0.9831	0.9948
Tech. shock (H)	ρ_Z	Beta	0.75	0.1	0.9973	0.9966	0.9946	0.9983
Tech. shock (F)	ρ_{Z^*}	Beta	0.75	0.1	0.7123	0.7057	0.6506	0.7582
Tech shock (S)	ρ_s	Beta	0.75	0.1	0.9961	0.9944	0.9903	0.9977
Demand shock (H)	ρ_b	Beta	0.5	0.05	0.7806	0.7659	0.7410	0.7861
Demand shock (F)	ρ_{b^*}	Beta	0.5	0.05	0.4995	0.4989	0.4297	0.5657
Training cost shock	σ_{fTR}	Inv gamma	0.01	2*	0.0117	0.0119	0.0110	0.0128
Migration cost shock	σ_{fMIG}	Inv gamma	0.01	2*	0.0285	0.0288	0.0266	0.0310
Trade cost shock	σ_τ	Inv gamma	0.01	2*	0.0059	0.0061	0.0055	0.0069
Tech. shock (H)	σ_Z	Inv gamma	0.01	2*	0.0530	0.0532	0.0491	0.0575
Tech. shock (F)	σ_{Z^*}	Inv gamma	0.01	2*	0.0287	0.0303	0.0261	0.0348
Tech shock (S)	σ_s	Inv gamma	0.01	2*	0.0542	0.0538	0.0487	0.0591
Demand shock (H)	σ_b	Inv gamma	0.01	2*	0.0155	0.0158	0.0146	0.0172
Demand shock (F)	σ_{b^*}	Inv gamma	0.01	2*	0.0040	0.0047	0.0030	0.0068
Global tech. shock	$\sigma_{\mathbb{X}}$	Inv gamma	0.01	2*	0.0290	0.0290	0.0268	0.0312

Figure 1A. Skill Premium by education level

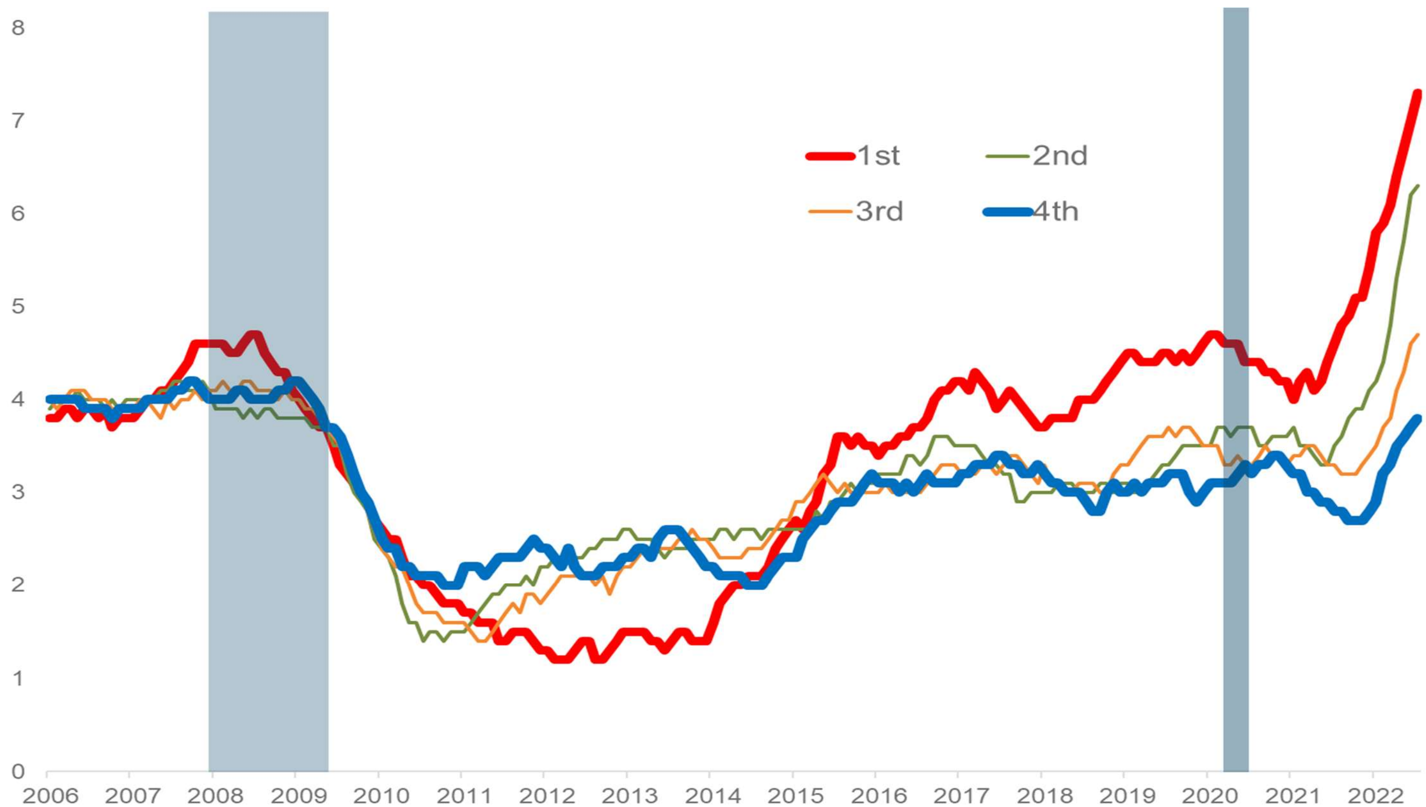
Note: Annual wage growth differential between workers with college and high school (or less). Source: Atlanta Fed wage tracker.

Figure 1B. Growth in Real Tuition Costs



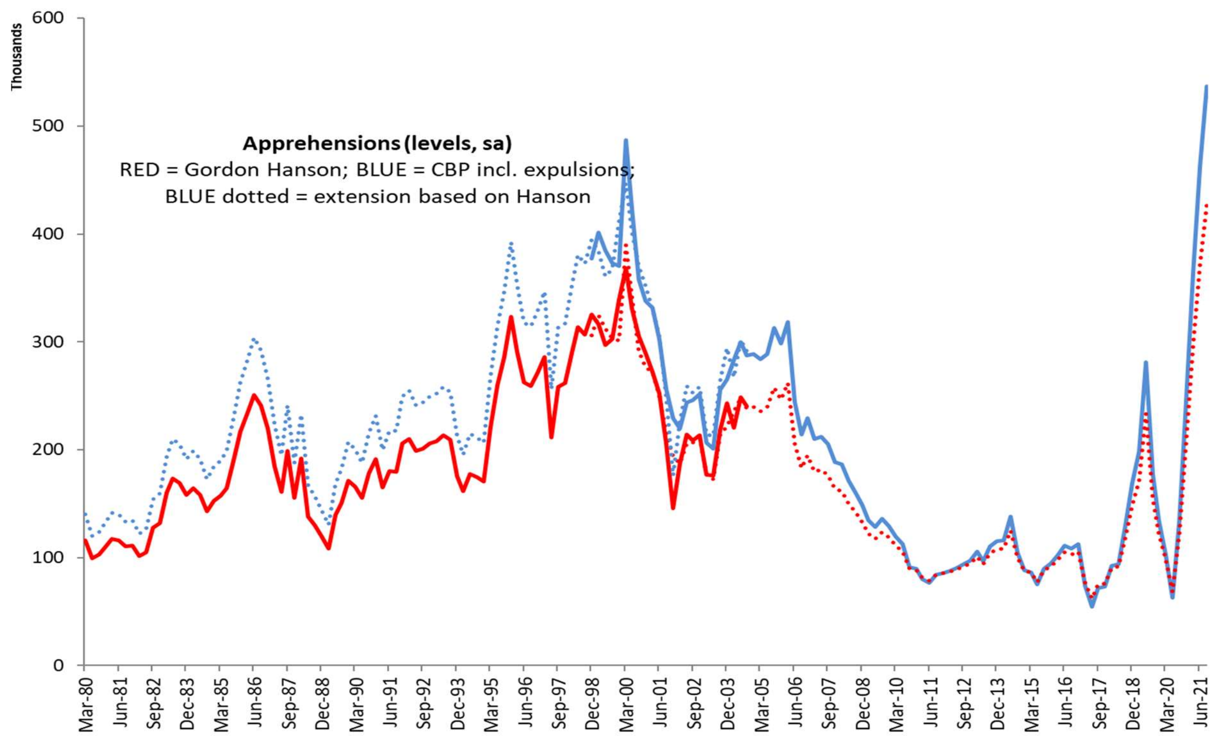
Note: Annual percentage change in tuition costs (tuition, other school fees, and childcare) deflated by the CPI index

Figure 2. Wage growth by Earnings Quartiles



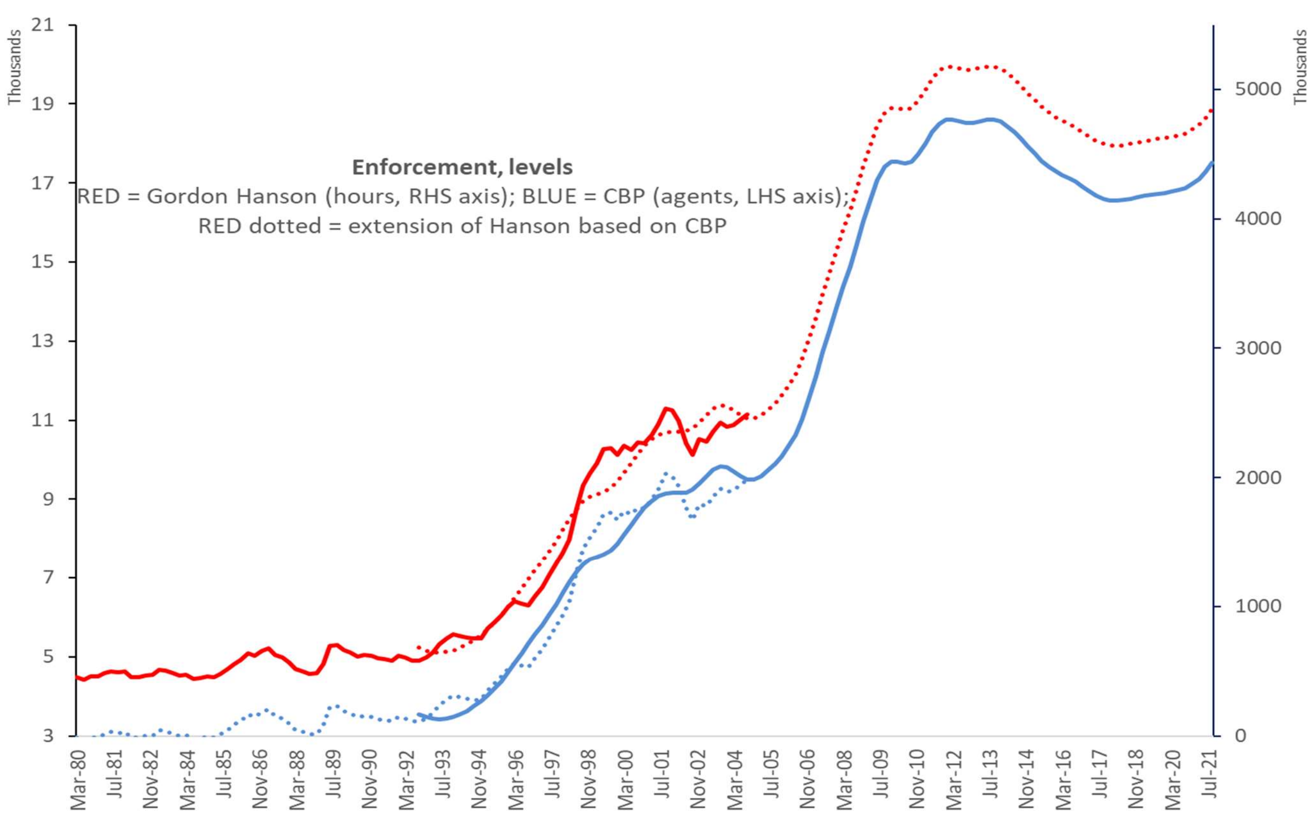
Note: Annual percentage change for different quartiles in the earnings distribution. Source: Atlanta Fed wage Tracker.

Figure 3. U.S./Mexico Border apprehensions



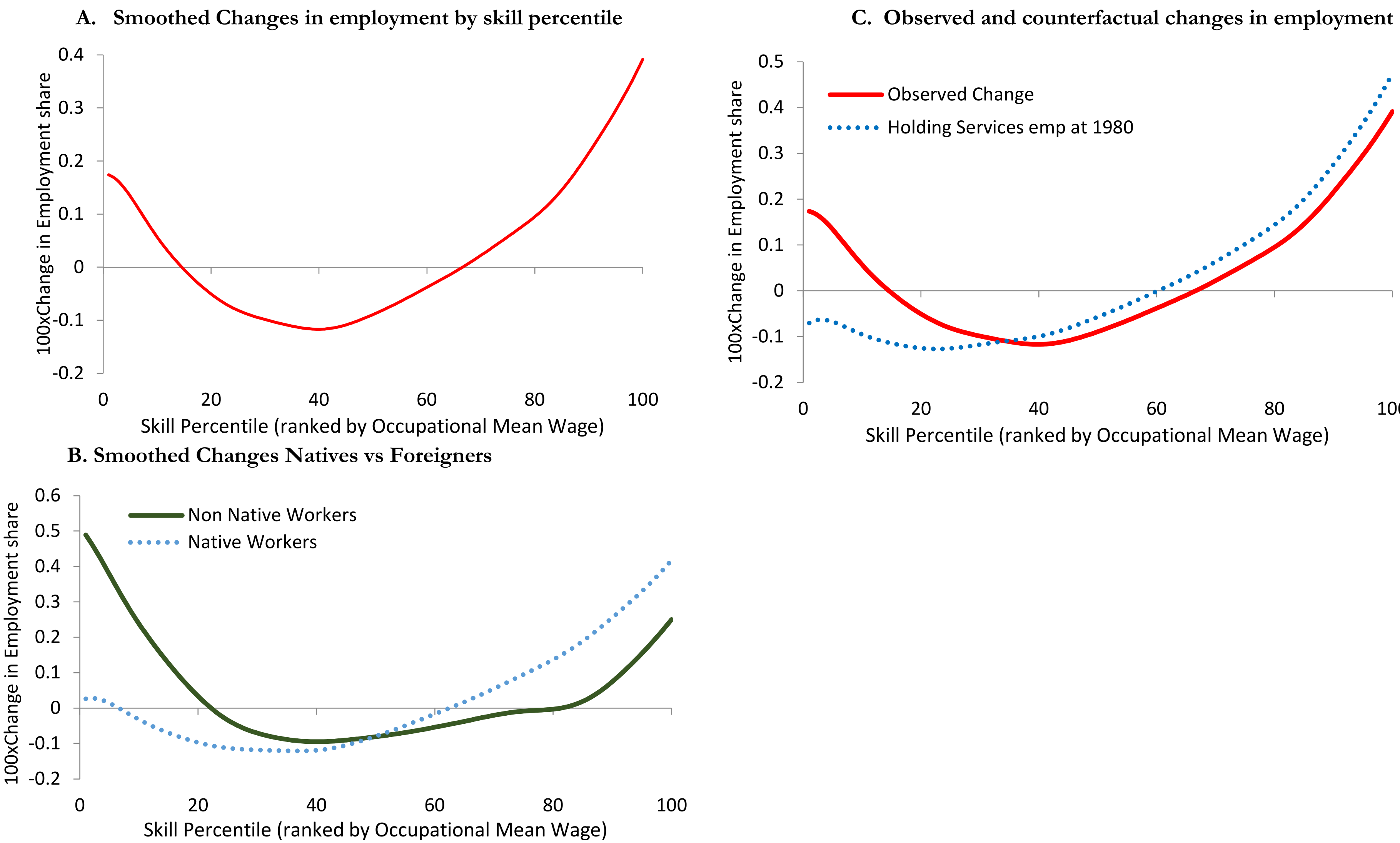
Note: See appendix for data sources and calculations.

Figure 4. U.S. border patrol officers in custody of the U.S/Mexico Border



Note: See appendix for data sources and calculations.

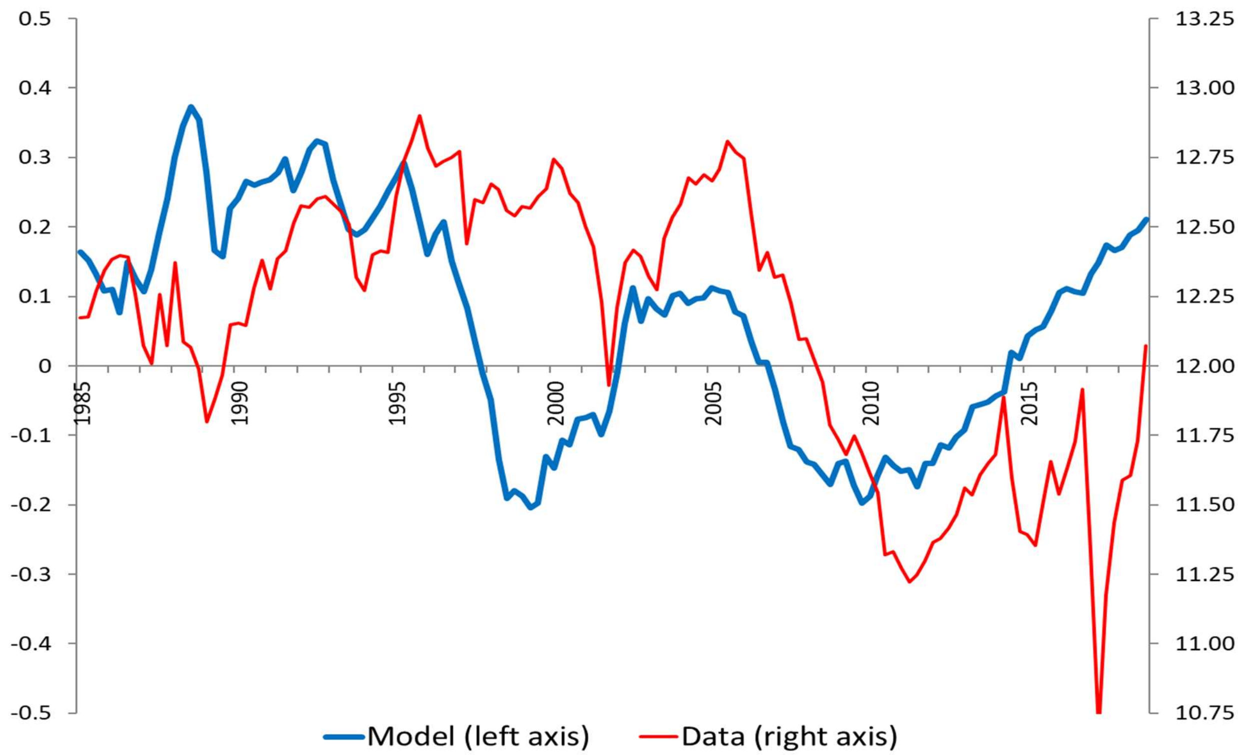
Figure 5. U.S. Labor Market (1980-2010)



Note: Census/ACS data is used to compute changes in employment shares and wages between 1980 and 2010. The occupations are sorted into 100 percentiles based on the mean occupational wages and the relative importance of occupations in 1980. The shares of total US employment are computed for each occupation, which are then aggregated at the percentile level. The change in shares is obtained as the simple difference between the share of total US employment in 2010 and 1980 for each percentile. For years 1990 and above, the average wages are estimated using the occupation share in 1980 as weights within each percentile. The smooth changes are obtained by using a locally-weighted polynomial regression between the change in employment shares (or average wages) and the corresponding percentiles.

Figure 6. Offshoring Costs and Migration flows: Data vs Model Predictions

A-Immigrant Entry



B-Trade/Offshoring costs

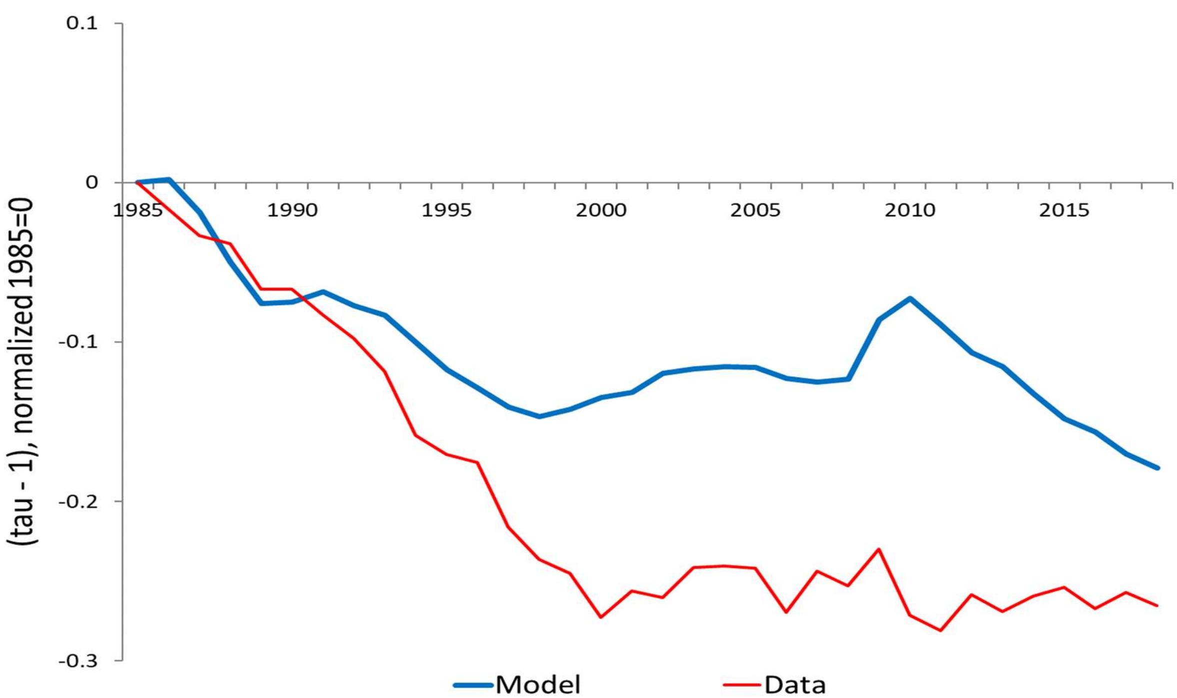
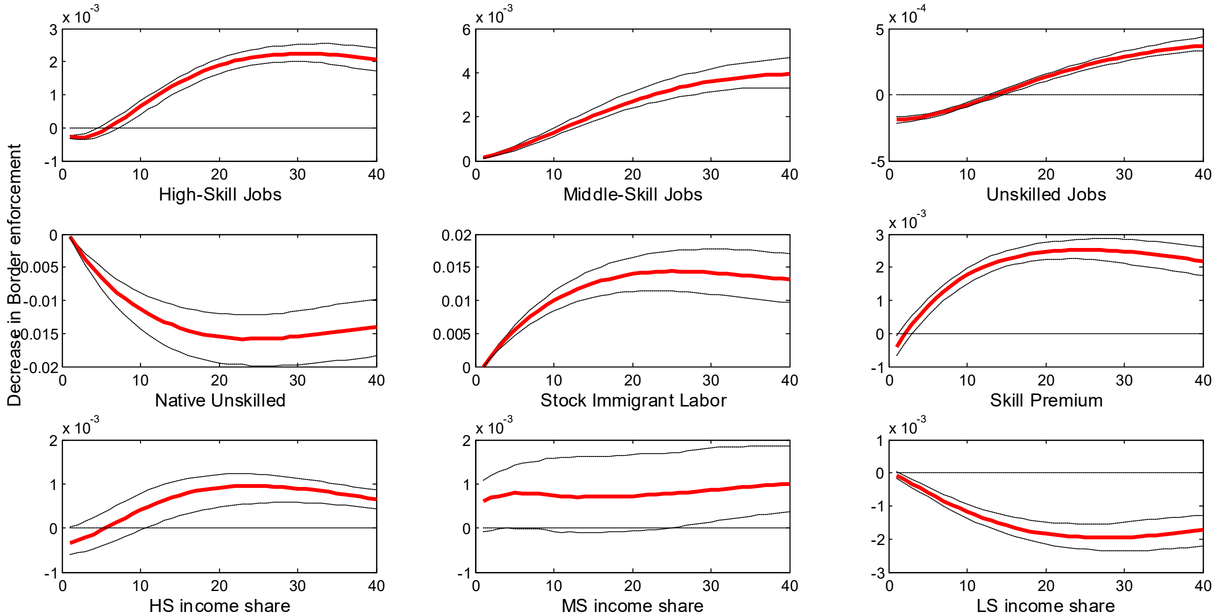
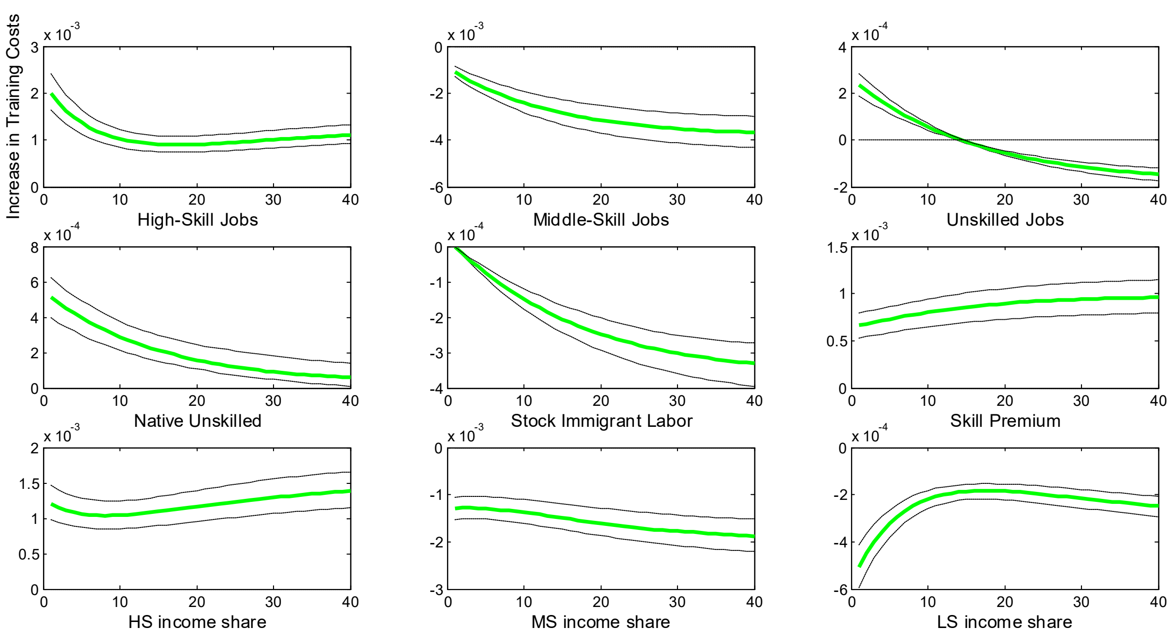


Figure 7. Impulse Response to a Decline in Border Enforcement (sunk migration costs)



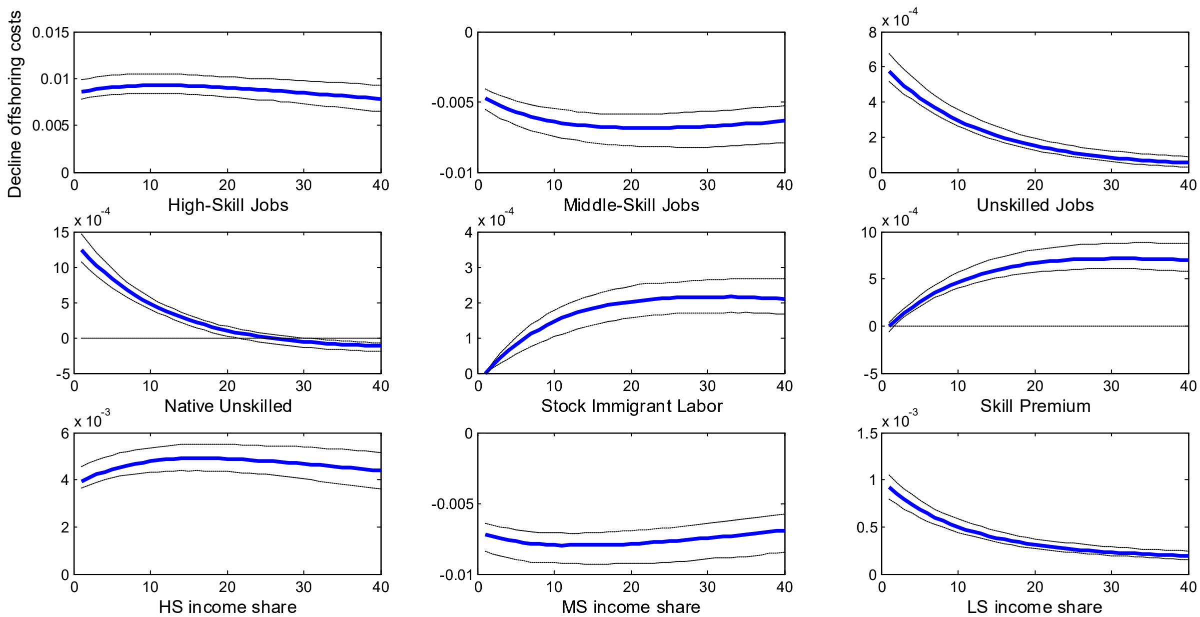
Note: The solid line is the median impulse response to one standard deviation of the estimated shock (see Table 1, for details), the dotted lines are the 10 and 90 percent posterior

Figure 8. Impulse Response to an increase in Training Costs



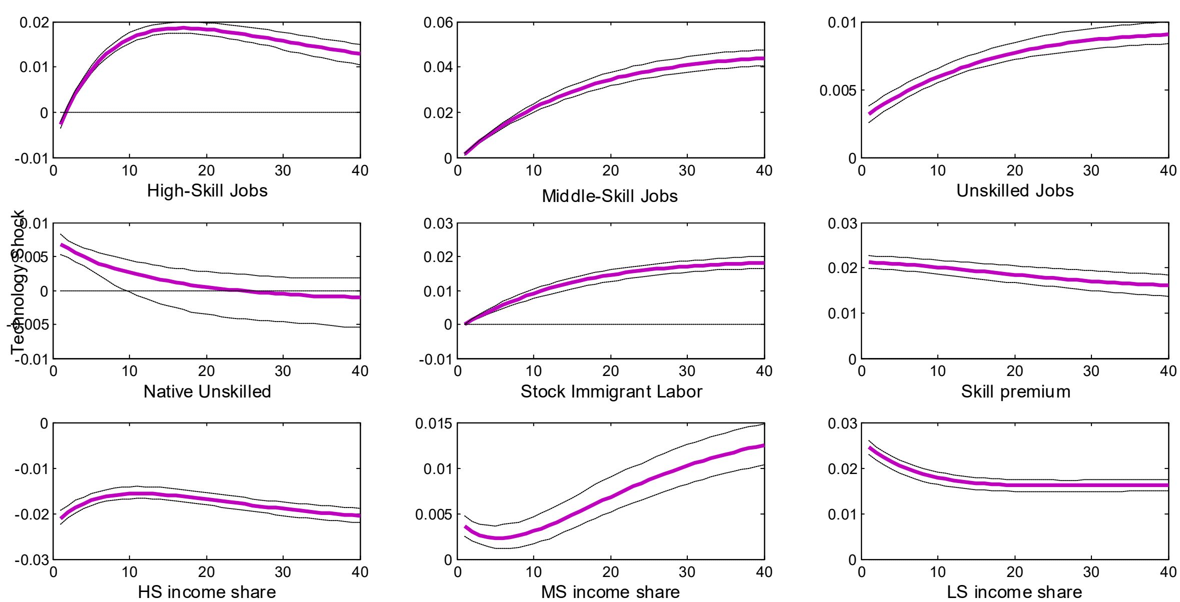
Note: The solid line is the median impulse response to one standard deviation of the estimated shock (see Table 1, for details), the dotted lines are the 10 and 90 percent posterior

Figure 9. Impulse Response to a Decline in Offshoring Costs



Note: The solid line is the median impulse response to one standard deviation of the estimated shock (see Table 1, for details), the dotted lines are the 10 and 90 percent posterior

Figure 10. Impulse Response to a positive Technology Shocks



Note: The solid line is the median impulse response to one standard deviation of the estimated shock (see Table 1, for details), the dotted lines are the 10 and 90 percent posterior

Figure 11. Shock historical decomposition of employment.

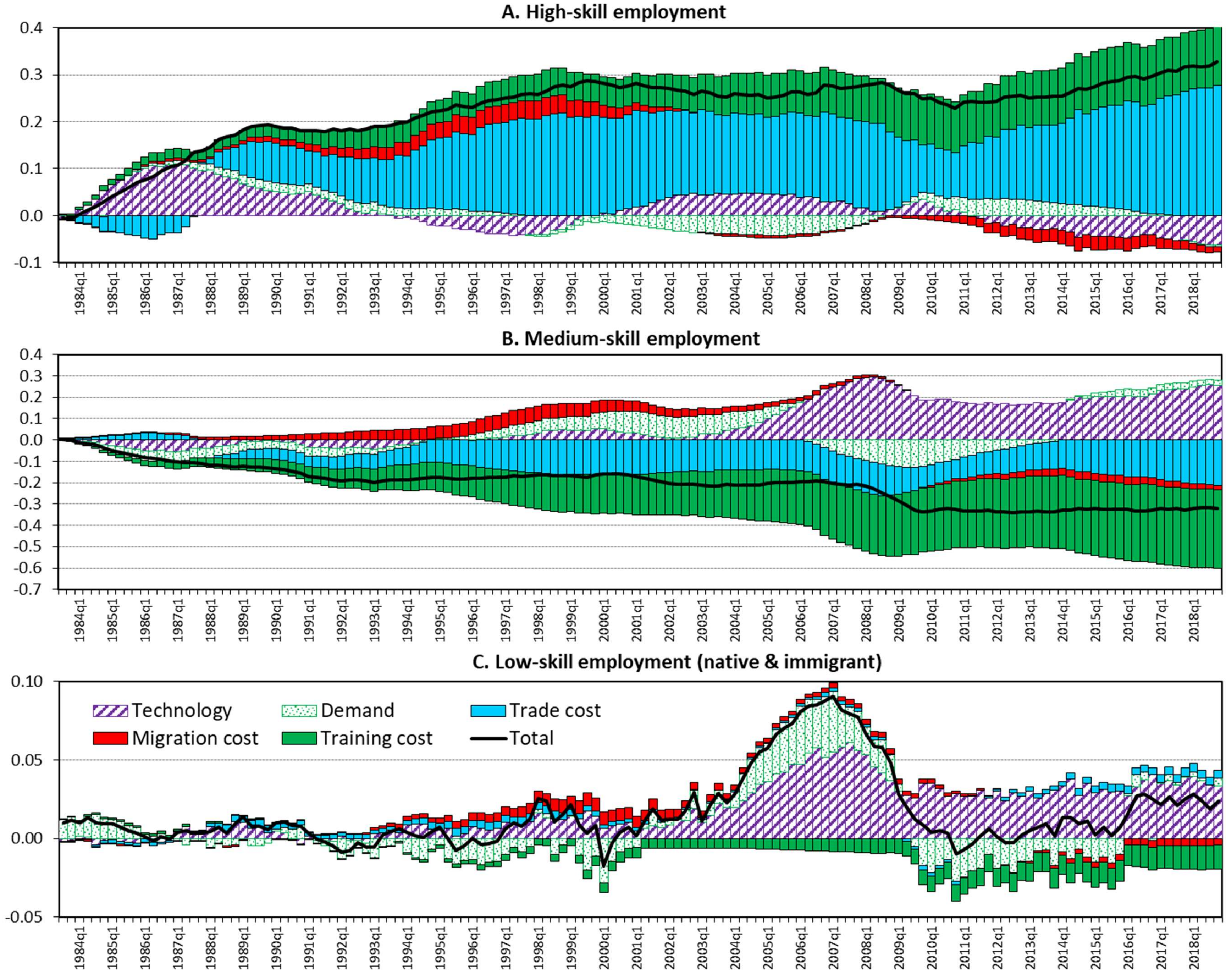


Figure 12. Shock historical decomposition of Earnings Shares

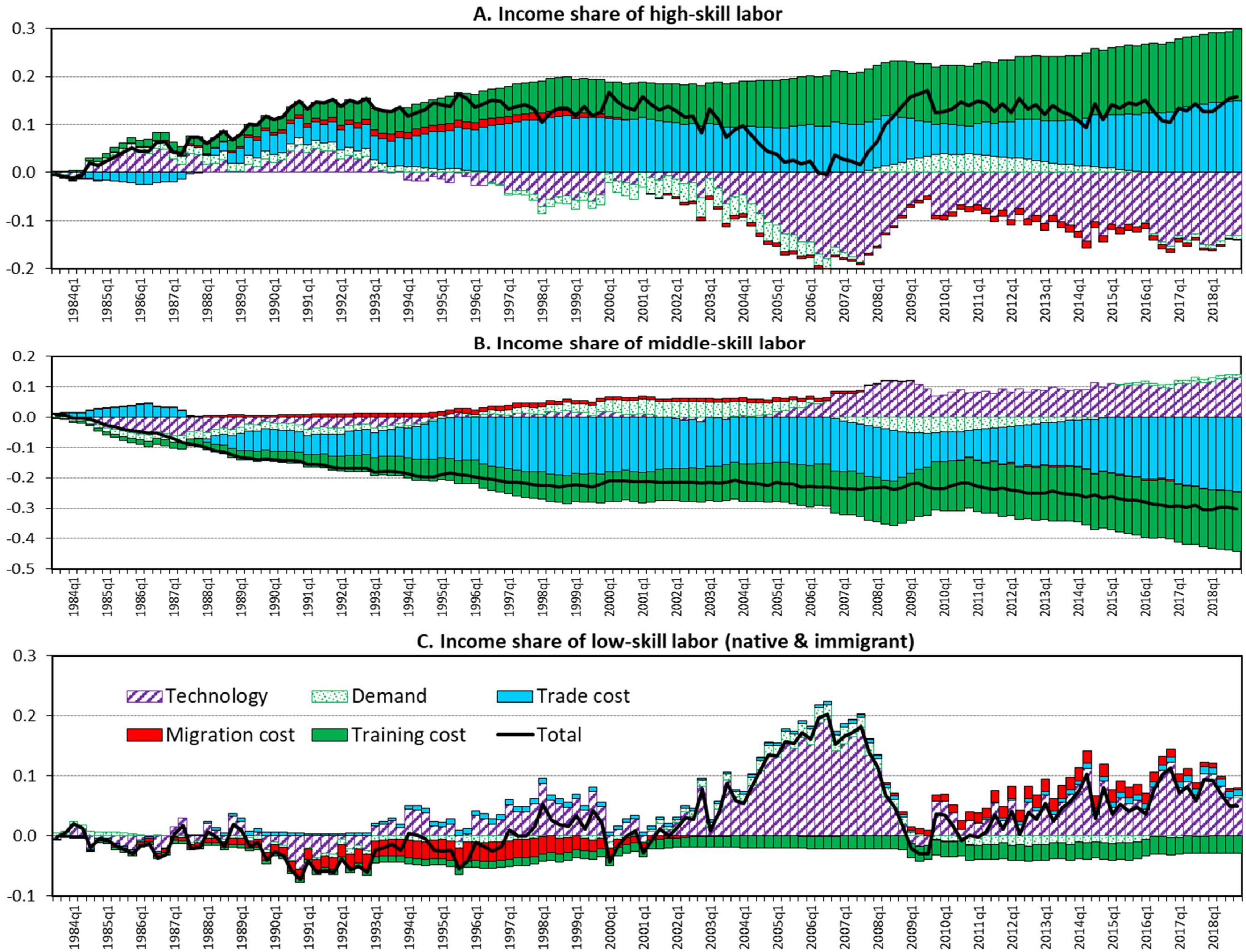
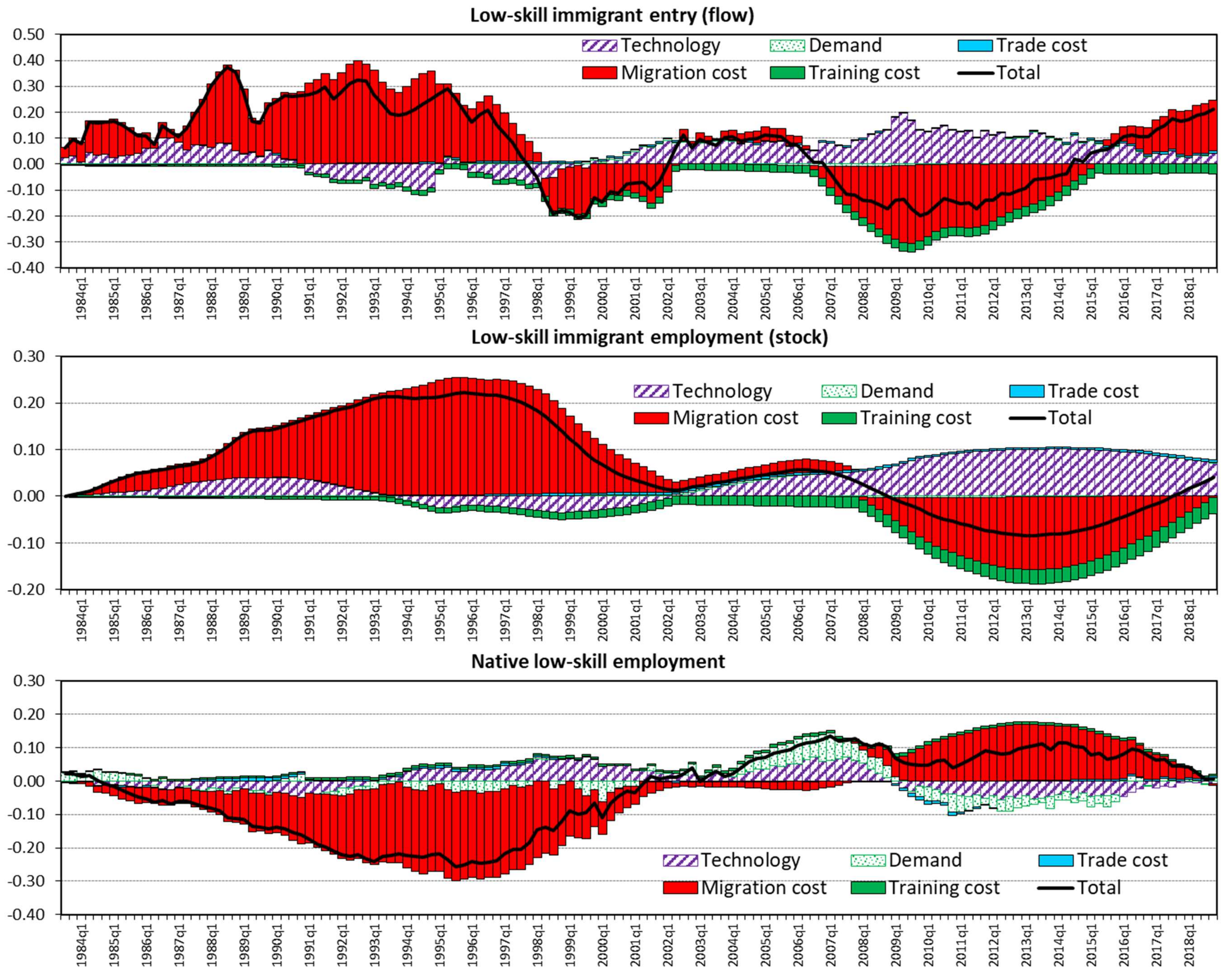
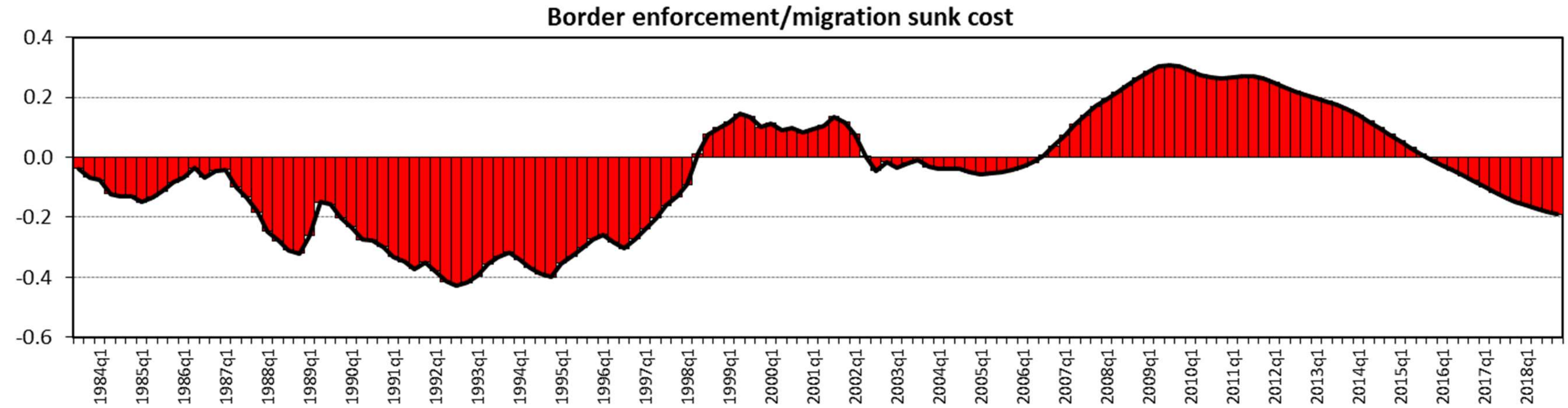
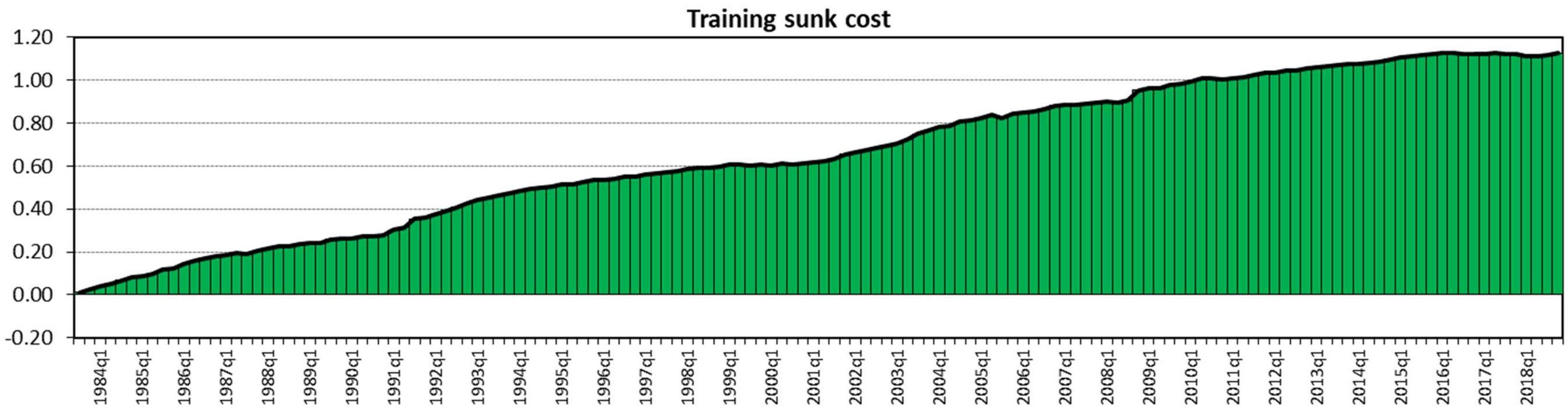


Figure 13. Shock historical decomposition of Migration Related Variables




Border enforcement/migration sunk cost
0.4
0.2
0.0
-0.2
-0.4
-0.6
1984q1
1985q1
1986q1
1987q1
1988q1
1989q1
1990q1
1991q1
1992q1
1993q1
1994q1
1995q1
1996q1
1997q1
1998q1
1999q1
2000q1
2001q1
2002q1
2003q1
2004q1
2005q1
2006q1
2007q1
2008q1
2009q1
2010q1
2011q1
2012q1
2013q1
2014q1
2015q1
2016q1
2017q1
2018q1


Training sunk cost
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1984q1
1985q1
1986q1
1987q1
1988q1
1989q1
1990q1
1991q1
1992q1
1993q1
1994q1
1995q1
1996q1
1997q1
1998q1
1999q1
2000q1
2001q1
2002q1
2003q1
2004q1
2005q1
2006q1
2007q1
2008q1
2009q1
2010q1
2011q1
2012q1
2013q1
2014q1
2015q1
2016q1
2017q1
2018q1