The Economic Impact of Mass Deportations

Javier Cravino, Andrei A. Levchenko, Francesc Ortega and Nitya Pandalai-Nayar*

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Abstract

This paper quantifies the effects of large-scale deportations on wages, prices, and real incomes in the United States. We impute the legal status for each worker in the American Community Survey by combining detailed individual information with group-level visa records. In 2024, 3.2% of US workers were unauthorized, but some regions and sectors were heavily dependent on unauthorized immigrant labor. We develop a dynamic quantitative framework with multiple regions, sectors and occupations, heterogeneous workers, and endogenous capital accumulation to study the economic impacts of removing unauthorized workers. We derive analytical expressions relating region- and occupation-specific real wages and sectoral relative prices to changes in the supply of immigrant workers, observable factor shares, and combinations of structural elasticities. Following the removal of 50% of unauthorized immigrants, in the short run average native real wages rise 0.15% nationally, driven by an increase in the capital-labor ratio. In the long run, however, native real wages fall in every state, and by 0.33% nationally, as capital gets decumulated in response to a lower population. At the same time native wages in the most immigrant-intensive occupations rise by up to 3.4% nationwide in the long run. Consumer prices in the sectors intensive in unauthorized workers – such as Farming – rise by about 1% relative to the price of the average consumption basket, while most other sectors experience negligible relative price changes.

Keywords: Immigration, unauthorized workers, wages, prices, welfare

JEL Codes: F22, F66, F68

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1 Introduction

The current administration has made it a priority to remove unauthorized immigrants from the United States. According to the U.S. Department of Homeland Security, 605,000 unauthorized immigrants were deported in 2025, with an additional 1.9 million departing voluntarily. The "One Big Beautiful Bill Act" allocated $75 billion in funding to Immigration and Customs Enforcement (ICE) to support these intensified deportation efforts. While one of the administration's stated goals is to boost the employment and wages of US natives, there is widespread concern that large-scale deportations could increase prices, particularly in sectors heavily reliant on immigrant labor such as construction and food staples. Such price increases may disproportionately impact lower-income segments of the US population, who spend a larger share of their income on food and housing.[1]

This paper studies the domestic economic impact of mass deportations. A key challenge in quantifying the impact of unauthorized immigrants is the lack of comprehensive information regarding the legal status of foreign-born workers in the US. We construct a nationally representative dataset that assigns (likely) legal status to all individuals in the American Community Survey (ACS), the primary national data source for information on the US workforce. We use this dataset to document the geographic, occupational, and sectoral distribution of unauthorized workers in the US. We then develop a quantitative model of the US economy to evaluate the impact of mass deportations on prices and wages.

We build on the methodology in Warren and Warren (2013), Passel and Cohn (2014), Borjas and Cassidy (2019), and Connor (2024) to assign legal status to individuals in the ACS, based on the workers' demographic characteristics and auxiliary data sources on border crossings, asylum seekers, and visas/permits. Our assignment distinguishes between foreign-born individuals with temporary authorization to work in the US and those unauthorized to do so. The latter group has grown substantially in the last few years (Pew Research Center, 2025). We augment the ACS with data on immigrant arrivals from official sources, resulting in a dataset representing the US population as of 2024.

We calculate that the employment share of immigrant workers (excluding naturalized citizens) in the United States is 10.0%.[2] In turn, 6.8% of workers are classified as authorized immigrants (including legal permanent residents, visa holders, DACA recipients, and those with temporary protection status) and 3.2% as unauthorized immigrants.[3] The presence of immigrant workers varies significantly across the United States. The states with the largest share of immigrant work-

[1]See, e.g., Department of Homeland Security (2025a), CBS News (2025), McKibbin, Hogan, and Noland (2024).

[2]According to the Bureau of Labor Statistics (2025 May release), the foreign-born share in the labor force in 2024 was 19.2% (based on CPS). Due to the similarity in employment rates, the foreign-born share in employment is also around 19%. The reason the immigrant share is only around 10% in our data is due to naturalized citizens: roughly half of the US foreign-born population are US citizens (approx. 25 million in 2024). The *foreign-born* share (i.e. naturalized citizens plus all other foreign-born individuals) in our data is 18.3%.

[3]The share of unauthorized workers in US employment is often estimated to be around 5% (e.g. Edwards and Ortega, 2017). The discrepancy with our figures is due to our narrower definition of unauthorized, which excludes individuals with temporary protection (e.g. DACA or TPS recipients) and places them instead in the authorized category.

ers are California (18%), followed by Washington, New Jersey–Delaware, New York, Florida, and Texas (13–15%). In California, 6% of all workers are unauthorized, followed by Washington, New Jersey–Delaware, Nevada, and Texas at about 5%. In contrast, in some states such as Montana and West Virginia, the share of immigrant workers is negligible. There is even greater heterogeneity across sectors of employment. Nationwide, in Farming an estimated 54% of the workforce are foreign immigrants, and an estimated 36% unauthorized to work in the US. Other sectors with a notable presence of unauthorized workers include Forestry and Fishing, Food and Drink Services, and Construction. Occupational heterogeneity paints a similar picture, with large concentrations of unauthorized workers in farming and construction occupations.

We use this dataset to discipline a multi-region, multi-sector, multi-occupation quantitative model of the US economy and the rest of the world. The model distinguishes between three types of workers —natives, authorized immigrants, and unauthorized immigrants— who choose locations based on real wages and idiosyncratic preferences, select occupations based on comparative advantage, or opt out of the labor force. Capitalist households own and accumulate the capital in the economy. Sectoral output is produced by employing labor from different occupations, capital, and intermediate inputs and can be traded across regions. In this setting, the removal of unauthorized workers triggers substitution towards natives and authorized workers, physical capital and intermediate inputs, different occupations and sectors, and towards goods produced in less affected regions. Changes in real wages in turn affect migration and labor supply decisions. Finally, the equilibrium capital stock changes endogenously and gradually in response to the change in the labor force.

We use a simplified version of the model to derive analytical formulas relating region- and occupation-specific real wage and relative price changes to changes in the supply of unauthorized workers, observable factor shares, and macro elasticities determined by structural parameters governing the model's multiple margins of adjustment. Following a reduction in the unauthorized population, two opposing forces act on the real wages of natives. First, because native and immigrant labor are imperfect substitutes, the fall in the relative supply of immigrant workers makes native labor relatively more abundant, reducing native wages all else equal. Second, the contraction in the labor force increases the capital-labor ratio, putting upward pressure on all wages.

The tension between these forces defines the distinction between the short and long run. In the long run, the population decline leads to capital decumulation to restore the steady-state capital-labor ratio. Consequently, the second effect dissipates, and average real wages for natives decrease in all regions, in rough proportion to the initial share of unauthorized workers in the regional wage bill. This decline in native wages is more pronounced if substitutability across natives and foreign immigrants, the substitutability across sectors and occupations, or the mobility across occupations, are low. However, despite this aggregate decline, native wages in specific immigrant-intensive occupations may increase if the elasticity of substitution between natives and immigrants is sufficiently high.

In the short run, the capital stock is fixed, so that the deportation shock leads to a higher capital-labor ratio. Native real wages can therefore temporarily increase if this capital deepening effect outweighs the negative impact of the increased relative supply of natives. Finally, removing unauthorized immigrants raises relative prices in immigrant-intensive sectors, in proportion to those sectors' labor share in gross output and the unauthorized workers' share in the sectoral wage bill. In addition, in the short run prices of the most capital-intensive sectors can fall.

We implement the full quantitative model on 48 regions roughly representing US states plus the rest of the world, 44 sectors, and 36 occupations. Following the methodology of Dekle, Eaton, and Kortum (2008) we express the model in gross proportional changes, resulting in a system of equations that depends on observable shares and structural elasticities. We calculate occupation, sector, and regional wage bill shares for each worker type directly from our ACS data, and obtain output, input, and trade shares from input-output tables and the Commodity Flow Survey. Finally, we use standard values from the literature for the structural elasticities.

We evaluate the consequences of removing 50% of all unauthorized workers (about 3.7 million) from the United States, uniformly across regions, sectors and occupations. This number is roughly in line with the Department of Homeland Security (DHS) stated target of removing 1 million people per year during the course of 2025-2028 (Department of Homeland Security, 2025b), i.e. 4 million total. In the long run, natives' average real wages fall in all US regions. The national decline is 0.33%, ranging from nearly 0.4–0.5% in the most-impacted states like Texas, California, and Washington, to approximately 0.2% in North Dakota, Maine, and Michigan. By contrast, in the short run native wages change in the opposite direction, increasing by an average of 0.15% across US regions. These short-run gains are highest in states with large unauthorized populations, rising by as much as 0.22–0.24% in California and Washington.

Despite the aggregate long-run decline, native real wages in immigrant-intensive occupations actually rise. Nationally, Farming occupations experience a 3.4% long-run increase in real wages, and some construction occupations a 0.8% increase. There is considerable within-occupation variation across regions here as well, with natives' wages in Farming rising by about 7% in some states.[4] Finally, real wages of immigrant workers rise both in the short and long run. Authorized workers' average real wages rise in every region, by a nationwide average of 3.2% in the long run. The largest wage gains are experienced by the unauthorized workers remaining in the US, whose real wages increase by 12.2% nationwide in the long run.[5]

In line with our analytical formulas, prices of unauthorized-intensive sectors rise relative to the price of the average consumption basket. The change in relative prices, however, is modest. For instance, despite the fact that the shock removes a large fraction of the Farm workforce, the relative producer prices of Farm goods only rise by 1.6% in the long run. To understand this result, we note that the share of unauthorized workers in the Farm wage bill is about 0.25, the labor share in

[4]We note, however, that native wages can decline in all occupations under plausible alternative values for the elasticity of substitution between natives and immigrants. This elasticity takes a value of 3 in our baseline calibration, which is in the mid-range of the estimates of the literature. If instead native and immigrant labor is not sufficiently substitutable, as estimated recently by Clemens and Lewis (2024), then natives' wages fall in all occupations.

[5]Of course, this finding pertains narrowly to wages, and does not incorporate the unauthorized workers' utility and psychic costs of experiencing a higher perceived probability of forcible detention and deportation.

Farms gross output is 0.2, and our calibration implies a relative-price macro-elasticity of roughly 0.5 due to the multiple adjustment margins in the model. Our analytical formula thus predicts a roughly 1.7% increase in relative Farm prices, which is closely in line with the finding from our full model.[6] Similarly, the relative producer prices in Forestry and Fishing rise by 1.4%. In the rest of the sectors relative producer price changes are even smaller, though in a few states relative producer price increases in Construction and Food and Beverages Manufacturing reach nearly 1%. Consumer price changes aggregate producer prices from different regions. In addition, inter- and intra-national trade will lead to substitution away from the regions in which producer prices rose the most. As a result, variation in consumer prices is more muted than in producer prices. At the extreme, Farming and Forestry and Fishing consumer prices rise respectively by 1.2% and 1.0% nationwide.

Finally, we evaluate the disparate impact of price changes on households and regions. Region-specific long-run CPI changes exhibit a range of about 0.7 percentage points across states, with the CPIs of Texas, California, Washington State, and New Jersey-Delaware rising by 0.2-0.3% relative to the national CPI, and that of North Dakota and West Virginia falling by nearly 0.4% relative to the national CPI. We use the US Consumer Expenditure Survey (CEX) to examine the variation across household-specific price indices induced by the removal of unauthorized workers. We compare the price index changes for households at the top 5% of the income distribution to the bottom 5%. Qualitatively, the removal of unauthorized migrants is regressive in the long run, as the price levels of low-income households rise by more than those of the high-income ones. This is due to the fact that lower-income households exhibit higher expenditure shares in food, and Farm prices increase the most. However, quantitatively this effect is minuscule, with the CPI of the bottom 5% of households increasing by only 0.02% more than the CPI of the top 5%. This is a direct consequence of the modest Farm relative consumer price changes (about 1.2%), and the insufficiently large differences across the income distribution in the food expenditure shares.

Literature Our paper contributes to the active recent literature that evaluates the impact of migration using quantitative trade and spatial models. Early work employed trade models in which a geographic unit is a country, and quantified the consequences of international migration for countries as a whole (e.g. di Giovanni, Levchenko, and Ortega, 2015; Aubry, Burzyński, and Docquier, 2016; Caliendo et al., 2021). More recently, several papers examined the impact of migration on sub-national units, such as US states, using models with rich internal geography, labor mobility across locations, and inter- and intra-national trade (e.g. Burstein et al., 2020; Burzyński et al., 2021; Peters, 2022; Bonadio, 2023; Khanna and Morales, 2024; Brinatti and Morales, 2025; Cruz and di Giovanni, 2025; Morales, 2025).[7] This strand of the literature typically focuses on long-term out-

[6] This corresponds to evaluating our formula for relative price changes in (15) at $0.25 \times 0.2 \times 0.5 \times \ln(0.5) \simeq 0.017$, where $\ln(0.5)$ reflects a 50% removal shock.

[7] This work in turn uses the tools developed by the new economic geography literature (see, among many others Allen and Arkolakis, 2014; Caliendo et al., 2017; Redding and Rossi-Hansberg, 2017; Caliendo, Dvorkin, and Parro, 2019; Galle, Rodríguez-Clare, and Yi, 2023; Rodríguez-Clare, Ulate, and Vasquez, 2025).

comes and abstracts from dynamic changes in congestion forces. One of our contributions is to incorporate gradual capital accumulation to understand how changes in the unauthorized population affects capital and housing congestion in the short run vs. the long run. In addition, existing work abstracts from the distinction between authorized and unauthorized immigrants. We evaluate policies that reduce the unauthorized population by combining our quantitative model with novel data on the geographic, occupational, and sectoral presence of unauthorized immigrants. Finally, we study how changes in the unauthorized population affect relative prices across goods produced with different immigrant intensities.

Our quantitative analysis also complements the vast empirical literature that estimates the labor market impacts of migration (see, among many others, Borjas, 2003; Peri and Sparber, 2009; González and Ortega, 2011; Ottaviano and Peri, 2012; Manacorda, Manning, and Wadsworth, 2012; Dustmann, Schönberg, and Stuhler, 2016). A related body of work examines the effect of immigration on consumer prices, such as personal services (Cortés, 2008; Cortés and Tessada, 2011; Farré, González, and Ortega, 2011; Butcher, Moran, and Watson, 2022; Furtado and Ortega, 2023) or housing prices (González and Ortega, 2013). More closely related is a smaller set of papers that estimates the economic impact of the unauthorized migrants using past migration episodes and policies (e.g. Edwards and Ortega, 2017; Machado, 2017; Borjas and Cassidy, 2019; Ortega, Edwards, and Hsin, 2019; East et al., 2023; Elias, Monras, and Vázquez-Grenno, 2025). We extend the approach to assign legal status used in these papers to allocate immigrants with temporary status and under DACA protection, and to document differences in unauthorized immigrant intensities across regions, occupations, and sectors. Our quantitative strategy allows us to evaluate the general equilibrium impact of hypothetical changes in immigration policies that are being implemented.

The rest of the paper is organized as follows. Section 2 introduces the data on immigrant legal status, and documents the distribution of foreign authorized and unauthorized workers in the US economy. Section 3 lays out the quantitative framework and states the analytical results. Section 4 describes the calibration and the quantitative results. Section 5 concludes. Details on the data, theory, quantification, and robustness are collected in the Appendix.

2 Where do foreign immigrants work?

This section documents the distribution of foreign immigrants across regions, occupations, and sectors in the US. Our primary data source is the 2023 American Community Survey (ACS). Following Passel and Cohn (2014), Borjas and Cassidy (2019) and Connor (2024), we build an individual-level assignment identifying likely unauthorized respondents, distinguishing those with temporary authorization to live and work in the United States (as of 2024) from those lacking such protections. In broad terms, this methodology follows the 'residual' approach of Warren and Warren (2013) which currently underpins the 'official' DHS estimates of the unauthorized US population size. This approach involves estimating the expected number of legal immigrants of certain demographics residing in the United States each year, based on various government sources regarding border crossings, asylum seekers, and visa or permit issuances. Using the demographic characteristics available for all foreign-born persons (both authorized and unauthorized) in the ACS, we assign the likelihood that each individual is authorized in order to match the size of each immigrant status group. We also adjust the ACS survey weights to incorporate recent immigration flows of highly transient populations (such as asylum seekers and beneficiaries of parole).[8] Appendix A.1 provides further details on the imputation of immigrant legal status procedure.

We use our immigrant status assignment to partition US workers into the following categories:

i. **Native workers** (N): US-born or naturalized citizens.

ii. **Authorized immigrants** (A): legal permanent residents, visa holders (H-1B, F-1, J-1, etc.), and those with protected status as of 2024 (DACA, advanced parole, Temporary Protected Status).

iii. **Unauthorized immigrants** (U): individuals unauthorized to live and work in the US.

Our interest is in the workforce. Thus, we restrict the sample to individuals ages 16-67. When computing earnings shares, we further restrict the sample to employed individuals with positive earnings (and leave out self-employed and retirees), as commonly done in the literature. However, when we examine the decision to participate in the labor market, we include the non-employed in the computation of employment-to-population ratios (employment probabilities).

2.1 Basic patterns

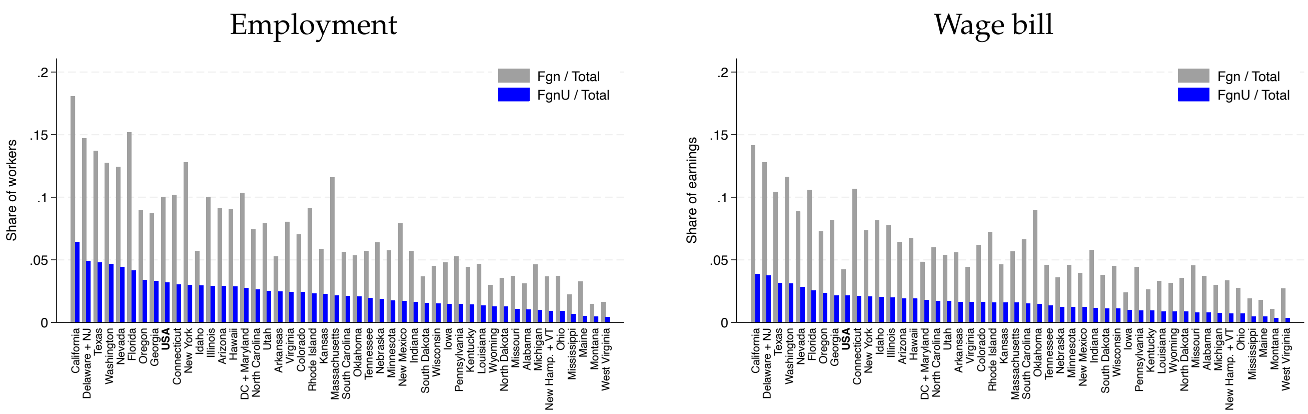
In our sample, foreign immigrants account for 10% of US employment. In turn, 6.8% and 3.2% are classified as A and U, respectively. We now document that immigrant and unauthorized workers are heavily clustered geographically, by industry, and by occupation. This potentially has important economic implications, as heterogeneous presence of immigrants across locations may lead to heterogeneous impacts on wages and prices.

Across geography: The left panel of Figure 1 plots the shares of immigrants combined ($A + U$), and unauthorized workers (U), in overall employment by state, sorted in descending order of unauthorized share in total employment. As expected, the highest immigrant share is found in California (around 18%), followed by Washington state, New Jersey-Delaware, New York, Florida, and Texas (13-15%).

The blue bars plot the shares of the unauthorized. Once again, the highest value belongs to California, where roughly 6% of all workers are unauthorized, followed by New Jersey-Delaware, Texas, Washington state, Nevada, and Florida, at around 5%. The right panel plots the shares of the wage bill. These are somewhat lower: in California, roughly 14% of the wage bill is accounted for by foreign immigrants, and 4% by the unauthorized.

[8] At the time of writing, the 2023 ACS is the most recent available wave of the survey.

Figure 1: Workers by region and migration status



Notes: This figure plots the shares of all foreign immigrants (authorized + unauthorized: grey bars) and unauthorized immigrants (blue bars) in total employment (left) and total wage bill (right) for the 47 US regions in the model.

Across industries: Figure 2 plots the total foreign immigrant shares and unauthorized shares in total sectoral employment and wage bill. Not surprisingly, the highest shares are found in the Farms sector, where nearly 54% of workers, accounting for 40% of the wage bill, are foreign immigrants. Unauthorized workers account for over 35% of all employment and 27% of the total wage bill in the Farms sector. Other sectors with a notable presence of unauthorized workers are Forestry and Fishing, Food and Drink Services, and Construction.

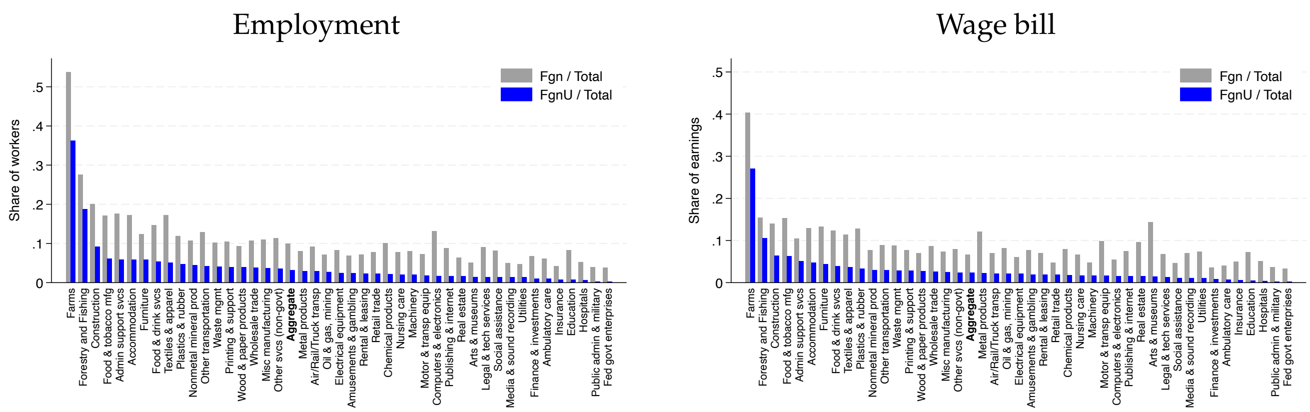
Across occupations The top panel of Figure 3 considers 12 large occupational groups. Not surprisingly, farmers, construction/mining workers, computers/STEM, and personal services are the occupational categories with the largest immigrant employment and wage bill shares. The blue bars indicate that over 45% of overall employment in farming occupations is unauthorized. Second are construction and extractive occupations, where 11% of employment and 10% of the wage bill is accounted for by the unauthorized workers. While the computers/STEM sector has a relatively large overall immigrant employment share of 12%, the unauthorized employment share in this sector is low at 2%.

The bottom panel of Figure 3 plots the same data but using the full 36-occupation classification implemented in the model below. The top three (narrow) occupations by immigrant share are farmers and two construction occupational categories (that do not include mining). The unauthorized shares in these narrower construction categories are around 15%.

3 Model

This section describes the theoretical framework. We relegate all derivations to Appendix B.1.

Figure 2: Workers by industry and migration status



Notes: This figure plots the shares of all foreign immigrants (authorized + unauthorized: grey bars) and unauthorized immigrants (blue bars) in total employment (left) and wage bill (right) for the 44 sectors in the model.

Preliminaries: There are $\mathcal{R}$ regions indexed by r, where $\mathcal{R}-1$ are within the United States and region $\mathcal{R}$ represents the rest of the world. There are $\mathcal{S}$ sectors, indexed by s, and $\mathcal{O}$ market occupations, indexed by o. Each region can produce a differentiated variety of output in each sector. In a subset of sectors, these varieties are traded across regions subject to iceberg trade costs. Time is indexed by t.

There are three types of worker households in the US, indexed by $i \in \{N, A, U\}$: natives, immigrants authorized to work in the US ("Authorized"), and immigrants not authorized to work ("Unauthorized"). Additionally, in each US region, a capitalist makes regional investment decisions and consumes regional goods, and a government makes exogenous purchases/requisitions of sectoral goods G_{rs}. Finally, in region $\mathcal{R}$, a representative household supplies labor and accumulates capital.

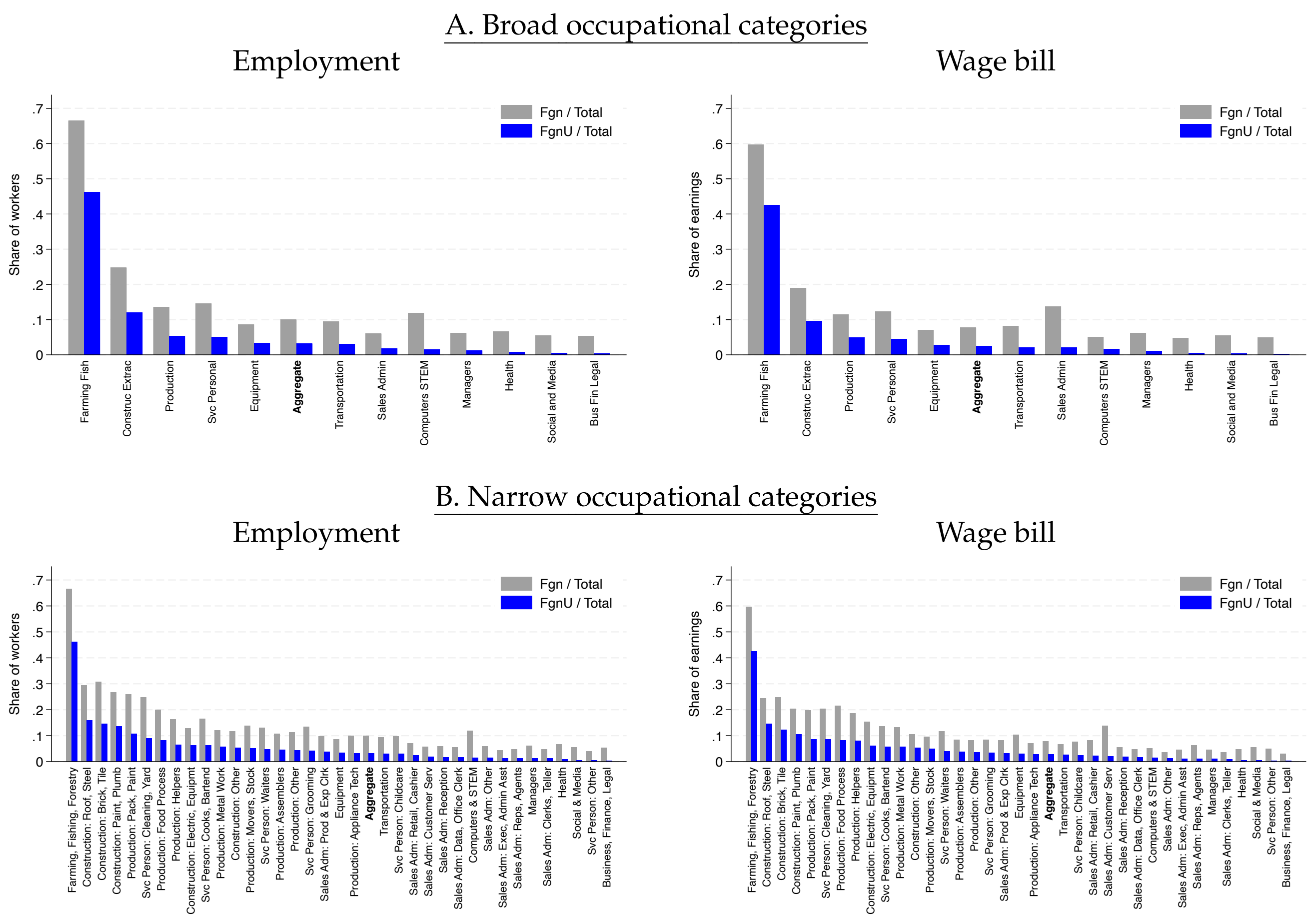
3.1 US households

3.1.1 Workers

Each US worker household h contains a continuum of members indexed by ω, and makes the following decisions in each period: (i) what fraction of its members to allocate to market activities; (ii) the occupational assignment of each member; (iii) what to consume; and (iv) where to locate within the US to begin the next period. Household preferences over US regions are governed by shifters $U_r^i u_{rt}(h)$, where U_r^i is common to all households of type i, and $u_{rt}(h)$ is idiosyncratic to household h.

Each household member has a preference over market vs. home production, governed by $\zeta_{jt}(\omega, h)$, where $j \in \{M, H\}$ indexes market and home production. A member participating in the market supplies $Z_{ro}^i a_t(h) \varepsilon_{ot}(\omega, h)$ efficiency units of labor to one occupation, where Z_{ro}^i is a type-region-occupation specific productivity shifter, $a_t(h)$ is a household-level productivity shifter, and

Figure 3: Workers by occupation and migration status



Notes: This figure plots the shares of all foreign immigrants (authorized + unauthorized: grey bars) and unauthorized immigrants (blue bars) in total employment for 12 broad occupational categories (top panel), and all 36 detailed occupations used in the model (bottom panel).

$\varepsilon_{ot}(\omega, h)$ is a member- and occupation-specific productivity shifter. Members working in the market consume

$$c^i_{M,rt}(\omega, h) = c^i_{M,rt}(h) / \pi^i_{M,rt}(h),$$

where $\pi^i_{M,rt}(h)$ is the fraction of household h engaged in market work, and

$$c^i_{M,rt}(h) = \prod_s \left[\frac{c^i_{rst}(h)}{\gamma_{st}(h)}\right]^{\gamma_{st}(h)},$$

is a bundle of sectoral goods purchased by the household. Household members allocated to home production consume

$$c^i_{H,rt}(\omega, h) = a_t(h)\, c^i_{H,r}, \tag{1}$$

where $c^i_{H,r}$ is a type- and region-specific constant.

Households maximize the expected sum of utilities of their members, subject to the budget constraint:

$$p_{rt}(h)\, c^i_{M,rt}(h) = a_t(h)\, \pi^i_{M,rt}(h)\, W^i_{rt}. \tag{2}$$

Here, $p_{rt}(h)$ is the unit price of $c^i_{M,rt}(h)$, $\pi^i_{M,rt}(h)\, W^i_{rt}$ is the market income of a household with $a_t(h) = 1$, and

$$W^i_{rt} \equiv \sum_o W^i_{rot} \pi^i_{rot} Z^i_{ro} \int_{\omega \in o} \varepsilon_{ot}(\omega)\, dG_\varepsilon(\omega)$$

is the income per-market worker. In this expression, W^i_{rot} denotes the price of an efficiency unit of type i labor in occupation o region r at time t, and π^i_{rot} is the fraction of type i market workers choosing occupation o at time t.

Timing: The timing is as follows. At the beginning of each period, households start in region r and allocate members ω between market and home production based on the preference shifters $\zeta_{jt}(\omega, h)$. After observing $a_t(h)$, $\gamma_{st}(h)$ and $\varepsilon_{ot}(\omega, h)$, households choose the occupations of their members and make consumption decisions, subject to the budget constraint (2). They then experience a location preference shifter $u_{rt+1}(h)$ for the next period. Based on this location preference shifter, but before observing any other $t+1$ shifters, they make a migration decision that puts them in a region at the beginning of the next period.

Household optimization: The value function of the household starting period t in region r is:

$$\mathcal{V}^i_{rt}(h) = \sum_{j \in \{M,H\}} \int_{\omega \in j} u^i_{j,rt}(\omega, h)\, dG_\zeta(\omega) + \beta \max_r \mathbb{E}_{\gamma,a} \mathcal{V}^i_{rt+1}(h),$$

where the expectation $\mathbb{E}_{\gamma,a}$ is taken over the distributions of preference and household-wide productivity shifters, γ and a. The current period utility of member ω is

$$u^i_{j,rt}(\omega,h) = a_t(h)\ln\left[c^i_{j,rt}(\omega,h)\right] + \zeta_{jt}(\omega,h) + \ln\left[U^i_r u_{rt}(h)\right].$$

Market participation decisions: Denote by Υ^i_{rt} the utility derived from consumption and labor market preferences (up to a constant):

$$\ln\Upsilon^i_{rt} \equiv \sum_{j\in\{M,H\}}\int_{\omega\in j}\left[V^i_{j,rt} + \zeta_{jt}(\omega,h)\right]dG_\zeta(\omega),$$

with $V^i_{M,rt} \equiv \ln\frac{W^i_{rt}}{P_{rt}}$, $V^i_{H,rt} \equiv \ln c^i_{H,r}$, and $\ln P_{rt} \equiv \mathbb{E}_{\gamma,a}\left[a_t(h)\ln p_{rt}(h)\right]$. At the beginning of a period in region r, households choose the fraction of members that work in the market to maximize Υ^i_{rt} after observing $\zeta_{jt}(\omega,h)$. We assume that $\zeta_{jt}(\omega,h)$ is drawn from a type-1 extreme value (Gumbel) distribution with cdf $G(\zeta_j) = \exp\left\{-e^{-\psi\zeta_j}\right\}$ and pdf $g(\zeta_j) = \psi\exp\left\{-\left(\psi\zeta_j + e^{-\psi\zeta_j}\right)\right\}$. Appendix B.1 computes the fraction of members that participate in the market:

$$\pi^i_{M,rt} = \left[\frac{W^i_{rt}}{\Upsilon^i_{rt}P_{rt}}\right]^\psi. \tag{3}$$

Occupation and consumption decisions: After observing productivity shifters, households allocate market workers to occupations to maximize total wage income. We assume that $\varepsilon_o(\omega,h)$ is distributed Fréchet with dispersion parameter $\theta+1$ and location parameter 1. Appendix B.1 shows that the household in region r allocates a fraction

$$\pi^i_{rot} = \frac{\left[Z^i_{ro}W^i_{rot}\right]^{\theta+1}}{\sum_{o'}\left[Z^i_{ro'}W^i_{ro't}\right]^{\theta+1}}, \tag{4}$$

of its market workers to occupation o. Given the preference shifters, the household demands for the sectoral goods are given by

$$P_{rst}c^i_{rst}(h) = \gamma_{st}(h)\,a_t(h)\,\pi^i_{M,rt}W^i_{rt},$$

where P_{rst} is the price of the sector s final good in region r.

Migration decisions: We assume that the idiosyncratic location preference parameters $u_{rt+1}(h)$ are drawn from a Fréchet distribution with shape parameter ν and location parameter 1. Using standard arguments, the fraction of type-i households that choose region $r \in \{1,\ldots,\mathcal{R}-1\}$ is given by

$$\pi^i_{rt+1} = \frac{\left[U^i_r \Upsilon^i_{rt+1}\right]^{\nu}}{\sum_{r'=1}^{\mathcal{R}-1}\left[U^i_{r'}\Upsilon^i_{r't+1}\right]^{\nu}}. \tag{5}$$

Aggregation: We can aggregate the household decisions within regions. Let H^i denote the mass of households of type i. Appendix B.1 shows that the total efficiency units of type i labor supplied to occupation o in region r can be written as:

$$L^i_{rot} \propto \; H^i \pi^i_{rt} \pi^i_{M,rt} Z^i_{ro} \; \left[\pi^i_{rot}\right]^{\frac{\theta}{1+\theta}}. \tag{6}$$

Total consumption expenditure by type i households of sectoral good s is

$$P_{rst} C^i_{rst} = \gamma_s H^i \pi^i_{rt} \pi^i_{M,rt} W^i_{rt}, \tag{7}$$

where $\gamma_s \equiv \int \mathrm{a}_t\left(h\right)\gamma_{st}\left(h\right) \mathrm{d}G_{\gamma,a}\left(h\right)$.

3.1.2 Regional capitalists

There is a capitalist in each region that accumulates the regional capital stock through investment and consumes the proceeds of renting capital to firms. The capitalist in region r solves

$$\max \sum_{t=0}^{\infty} \beta^t U\left(C^K_{rt}\right)$$

subject to:

$$P_{rt}\left[C^K_{rt} + I_{rt}\right] \leq R_{rt} K_{rt},$$

where capital evolves according to $K_{rt+1} = I_{rt} + \left[1-\delta\right] K_{rt}$ and K_0 is given. Here C^K_{rt} is the capitalist consumption, P_{rt} is the unit price of the good consumed and invested by the capitalist, K_{rt} is the capital stock, δ is the depreciation rate, and R_{rt} is the price of capital services in production. The capitalist consumption and investment good are produced using the same technology according to

$$C^K_{rt} + I_{rt} = \prod_s \left[\frac{X^K_{rst}}{\gamma_s}\right]^{\gamma_s},$$

where X^K_{rs} denotes the use of the region r sectoral good s by the capitalist. Note that we have assumed that the sectoral weights for the capitalist γ_s coincide with the aggregate sectoral weights of the households.

3.2 Rest of the world households

The rest of the world is populated by a household of type $i = A$ that has mass $H_{\mathcal{R}}$ and is comprised of a continuum of members that can only work in the market. The household must locate in region $\mathcal{R}$ but can choose the occupations of its members, capital, and consumption. The household maximizes:

$$\max \sum_{t}^{\infty} \beta^t U\left(C_{\mathcal{R}t}\right),$$

subject to the budget constraint

$$P_{\mathcal{R}t}\left[C_{\mathcal{R}t} + I_{\mathcal{R}t}\right] = R_{\mathcal{R}t}K_{rt} + W_{\mathcal{R}t}H_{\mathcal{R}t},$$

where capital evolves according to $K_{\mathcal{R}t+1} = I_{\mathcal{R}t} + [1-\delta]\, K_{\mathcal{R}t}$ and $K_{\mathcal{R}0}$ is given. Here $W_{\mathcal{R}t}H_{\mathcal{R}t}$ is the total labor income in region $\mathcal{R}$. The consumption and investment good in $\mathcal{R}$ are produced using the same technology:

$$C^K_{\mathcal{R}t} + I_{\mathcal{R}t} = \prod_s \left[\frac{X_{\mathcal{R}st}}{\gamma_s}\right]^{\gamma_s},$$

where $X_{\mathcal{R}st}$ denotes the use of the region $\mathcal{R}$ sectoral good s for investment and consumption.

Household members in $\mathcal{R}$ supply $Z^i_{\mathcal{R}o}a\left(h\right)\varepsilon_{ot}\left(\omega, h\right)$ efficiency units of labor to one occupation, where $\varepsilon_{ot}\left(\omega, h\right)$ is distributed Fréchet with dispersion parameter $\theta + 1$ and location parameter 1. The fraction of members in occupation o is given by equation (4).

3.3 Government

There is a government that makes exogenous purchases/requisitions of the aggregate sectoral goods in each region G_{rst}. These purchases that are in zero world net supply in revenue terms, $\sum_r P_{rst}G_{rst} = 0\ \forall s$. As will be clear in our calibration section, the G_{rst}'s are wedges required to perfectly match the observed the regional variation in sectoral absorption in the data as well as the observed sectoral trade deficits and surpluses.

3.4 Technologies

Producers of intermediate sectoral goods: Each region can produce a differentiated intermediate good in each sector using a bundle of labor L_{rst}, capital K_{rst}, and intermediate inputs M_{rst}. The production function for region r's variety of sector s good is given by:

$$Y_{rst} = \left[K^{\alpha_s}_{rst}L^{1-\alpha_s}_{rst}\right]^{\kappa_s} M^{1-\kappa_s}_{rst}.$$

Here M_{rst} is a composite of intermediate goods from multiple sectors,

$$M_{rst} = \Pi_{s'} M_{rs'st}^{\gamma_{s's}},$$

with $M_{rs'st}$ denoting the usage of intermediates from sector s' in production of sector s.

The labor composite in each sector combines workers from multiple occupations:

$$L_{rst} = \left[\sum_{o} \left[\bar{\phi}_{rso} \right]^{\frac{1}{\eta}} \left[L_{rsot} \right]^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}},$$

Here L_{rsot} is a bundle of occupation o labor used in production of sector s in region r, and η is the elasticity of substitution across occupations. Occupation-level bundles are composed of natives and immigrants:

$$L_{rot} = \left[\left[\bar{\lambda}_{ro}^{N} \right]^{\frac{1}{\epsilon}} \left[L_{rot}^{N} \right]^{\frac{\epsilon-1}{\epsilon}} + \left[\bar{\lambda}_{ro}^{F} \right]^{\frac{1}{\epsilon}} \left[L_{rot}^{F} \right]^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}.$$

Here L_{rot}^{N} and denotes the efficiency units of native labor in region r and occupation o, and

$$L_{rot}^{F} = \left[\left[\bar{\lambda}_{ro}^{A} \right]^{\frac{1}{\sigma}} \left[L_{rot}^{A} \right]^{\frac{\sigma-1}{\sigma}} + \left[\bar{\lambda}_{ro}^{U} \right]^{\frac{1}{\sigma}} \left[L_{rot}^{U} \right]^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}},$$

where L_{rot}^{A} and L_{rot}^{U} respectively denote the efficiency units of authorized and unauthorized immigrants. In these labor aggregates, ϵ is the elasticity of substitution between natives and immigrants, and σ is the elasticity of substitution between authorized and unauthorized immigrants.

Producers of final sectoral goods: Each region produces a non-tradeable sectoral composite good by aggregating sectoral varieties produced by all regions:

$$X_{rst} = \left[\sum_{r'} \left[\bar{\omega}_{r'rs} \right]^{\frac{1}{\chi}} \left[Y_{r'rst} \right]^{\frac{\chi-1}{\chi}} \right]^{\frac{\chi}{\chi-1}}.$$

Here $Y_{r'rst}$ is the amount of region r' sector s output used by region r, and χ is the elasticity of substitution across regional varieties. The sectoral good X_{rst} can be used for consumption, investment, and as an intermediate input in region r.

3.5 Market clearing and equilibrium

Market clearing for the labor bundle in occupation o satisfies

$$L_{rot} = \sum_{s} L_{rsot}. \tag{8}$$

Market clearing for sectoral regional varieties satisfies

$$Y_{rst} = \sum_{r'} Y_{rr'st}. \tag{9}$$

Market clearing for the capital stock satisfies,

$$K_{rt} = \sum_{s} K_{rst}. \tag{10}$$

Finally, market clearing for final regional goods satisfies

$$X_{rst} = \sum_{i} C^{i}_{rst} + X^{K}_{rst} + \sum_{s'} M_{rss't} + G_{rst}. \tag{11}$$

Equilibrium: An equilibrium is a set of prices and quantities $\{P_{rt}\}_{\forall r,t}$, $\left\{\Upsilon^{i}_{rt}, \pi^{i}_{M,rt}, W^{i}_{rt}, \pi^{i}_{rt}\right\}_{\forall r,i,t}$, $\{C^{i}_{rst}\}_{\forall rs,i,t}$, $\{W_{rot}, L_{rot}\}_{\forall ro,t}$, $\{L^{N}_{rot}, L^{A}_{rot}, L^{U}_{rot}\}_{\forall ro,t}$, $\{W^{i}_{rot}, \pi^{i}_{rot}\}_{\forall ro,t}$, $\{L^{F}_{rot}, W^{F}_{rot}\}_{\forall ro,t}$, $\{Y_{rst}, L_{rst}, K_{rst}, X^{K}_{rst},\}_{\forall rs,t}$, $\{P_{rst}, P^{y}_{rst}, W_{rst}\}_{\forall rs,t}$, $\{X_{rst}\}_{\forall rs,t}$, $\{M_{rss't}\}_{\forall rss',t}$, $\{Y_{r'rst}\}_{\forall r'rs,t}$, $\{L_{rsot}\}_{\forall rso,t}$ and $\{R_{rt}, I_{rt}, C^{K}_{rt}\}_{\forall r,t}$ such that (i) consumers maximize utility; (ii) producers minimize costs; and (iii) all markets clear. We characterize the equilibrium in Appendix B.1.

3.6 Analytical results

This section provides formulas linking wage and price changes to changes in the mass of unauthorized workers in a simplified version of the model. We use lowercase letters to denote the cumulative log change of a variable from the initial (pre-shock) steady state, $x_t \equiv \ln X_t - \ln X_0$. Lowercase letters without a time subscript denote initial (pre-shock) values. We begin by stating two propositions. The first relates price and wage changes to changes in region-level equilibrium labor quantities. The second relates these labor quantities to the exogenous change in the national-level mass of unauthorized workers. We then use these two propositions to highlight the impact of changes in the number of unauthorized workers on natives' and immigrants' real wages and goods prices at different time horizons.

Proposition 1 ***(Relative wages)*** *Assume that (i) regions do not trade, $\bar{\omega}_{r'rs} = 0$ for $r' \neq r$; (ii) there are two occupations, (iii) all sectors have the same input requirements $\gamma_{s's} = \gamma_s$; and (iv) all foreign immigrants are unauthorized, $\bar{\lambda}^{A}_{ro} = 0 \, \forall r, o$. Denote by $w_{rt} \equiv \sum_i \lambda^i_r w^i_{rt}$ and $l_{rt} \equiv \sum_i \lambda^i_r l^i_{rt}$ the cumulative change in the average wage and the aggregate labor supply in region r, respectively, where the weights $\lambda^i_r \equiv \frac{\sum_o W^i_{ro} L^i_{ro}}{\sum_{o'} W_{ro'} L_{ro'}}$ are the shares of type-i workers in the total wage bill of region r. To a first order approximation, starting from a steady state at date $t = 0$, the cumulative change in average real wages is related to changes in regional* *labor supplies by*

$$w_{rt} - p_{rt} = -\alpha_r \left[k_{rt} - l_{rt}\right] = -\alpha_r \sum_{\tau=0}^{t-1} b^{\tau} \left[l_{rt-\tau} - l_{rt-\tau-1}\right], \tag{12}$$

where $\alpha_r \equiv \frac{\sum_s R_r K_{rs}}{\sum_s W_{rs} L_{rs} + \sum_s R_r K_{rs}}$ *is the aggregate capital share in value added in region r and* $b \equiv \alpha_r + [1-\alpha_r]\,\beta\,[1-\delta] < 1$*. Changes in relative wages are given by:*

$$w_{rt}^{N} - w_{rt} = \xi_r \lambda_r^{U} \left[l_{rt}^{U} - l_{rt}^{N}\right]; \quad w_{rt}^{U} - w_{rt} = -\xi_r \lambda_r^{N} \left[l_{rt}^{U} - l_{rt}^{N}\right], \tag{13}$$

and

$$w_{rot}^{N} - w_{rt} = \xi_{ro}^{N} \lambda_r^{U} \left[l_{rt}^{U} - l_{rt}^{N}\right]; \quad w_{rot}^{U} - w_{rt} = -\xi_{ro}^{U} \lambda_r^{N} \left[l_{rt}^{U} - l_{rt}^{N}\right]. \tag{14}$$

The changes in relative prices are:

$$p_{rst} - p_{rt} = \kappa_s \left[[1-\alpha_s]\, \xi_r^{s} \left[\lambda_r^{U} - \lambda_{rs}^{U}\right] \left[l_{rt}^{U} - l_{rt}^{N}\right] - \frac{\alpha_s - \alpha_r}{\alpha_r} \left[w_{rt} - p_{rt}\right] \right], \tag{15}$$

where $\lambda_{rs}^{i} \equiv \frac{\sum_o W_{ro}^{i} L_{rso}^{i}}{\sum_{o'} W_{ro'} L_{rso'}}$ *is the share of type-i workers in the wage bill of sector s. The constants appearing in the formulas are composite elasticities, defined as follows:*

$$\xi_r \equiv \frac{\theta + v_r}{\theta \mu_r + \epsilon \bar{\eta}_r} \geq 0 \quad ; \quad \xi_r^{s} \equiv \frac{\theta + \epsilon}{\theta \mu_r + \epsilon \bar{\eta}_r} \geq 0; \quad \xi_{ro}^{i} \equiv \frac{\theta + v_{ro}^{i}}{\theta \mu_r + \epsilon \bar{\eta}_r}, \tag{16}$$

where $\bar{\eta}_r = \eta\,[1-\varsigma_r] + \varsigma_r \geq 0$ *is the aggregate elasticity of substitution across occupations, which is a weighted average of the occupation elasticity of substitution within sectors* η *and the elasticity of substitution across sectors (which equals 1 in our model). The weighting factor is given by* $\varsigma_r \equiv \sum_s \frac{[\phi_{rs1} - s_{r1}]^2 s_{rs}}{s_{r1}[1-s_{r1}]}$*, where* $s_{rs} \equiv \frac{W_{rs} L_{rs}}{\sum_s W_{rs} L_{rs}}$ *denotes the share of sector s in the total wage bill, and* $\phi_{rso} \equiv \frac{W_{ro} L_{rso}}{W_{rs} L_{rs}}$ *is the share of occupation o in the wage bill of sector s. Finally,* $v_r \equiv [1-\omega_r]\,\epsilon + \omega_r \bar{\eta}_r$*,* $\mu_r \equiv [1-\omega_r]\,\bar{\eta}_r + \omega_r \epsilon$*, and* $v_{ro}^{i} \equiv \left[1-\omega_{ro}^{i}\right] \epsilon + \omega_{ro}^{i} \bar{\eta}_r$ *are linear combinations of the elasticities of substitution across occupations and worker types, where the weights are defined as* $\omega_r \equiv \frac{1 - \sum_o \pi_{ro}^{N} \lambda_{ro}^{N}}{1 - \lambda_r^{N}} \leq 1$*,* $\omega_{ro}^{i} \equiv \frac{1-\lambda_{ro}^{i}}{1-\lambda_r^{i}}$*, and* $\lambda_{ro}^{i} \equiv \frac{W_{ro}^{i} L_{ro}^{i}}{W_{ro} L_{ro}}$ *is the share of type-i workers in the wage bill of occupation o.*[9]

Proof. See Appendix B.2. ■

Proposition 2 ***(Labor supply)*** *Assume that conditions (i)-(iv) of Proposition 1 hold, and that the labor force participation rates are the same for natives and immigrants:* $\pi_{M,r}^{N} = \pi_{M,r}^{U} = \pi_{M,r}$*. In response to any sequence of changes in the mass of unauthorized workers* h_t^{U} *starting at* $t \geq 1$ *and converging to some*

[9] Appendix B.2 also presents formulas for the change in the occupational and the sectoral wage aggregates, w_{ro} and w_{rs}.

constant h^U_∞ as $t \to \infty$, the long run response of the relative labor supplies is

$$l^U_{r\infty} - l^N_{r\infty} = \xi^l_r h^U_\infty \tag{17}$$

with

$$\xi^l_r = \left[1 + \pi_{H,r}\psi\xi_r + \nu\left[\pi_{M,r}\xi_r - \sum_{r'=1}^{\mathcal{R}-1}\pi_{rr'}\pi_{M,r'}\xi_{r'}\right]\right]^{-1} > 0,$$

where $\pi_{H,r} \equiv 1 - \pi_{M,r}$ is the fraction of workers outside of the labor force and $\pi_{rr'} \equiv \left[\pi^N_{r'}\left[1 - \lambda^N_{r'}\right] + \pi^U_{r'}\lambda^N_{r'}\right]\frac{1+\pi_{H,r}\psi\xi_r+\pi_{M,r}\nu\xi_r}{1+\pi_{H,r'}\psi\xi_{r'}+\pi_{M,r'}\nu\xi_{r'}}$. In addition, if migration is inelastic ($\nu = 0$), the regional labor supplies at any period t are given by

$$l^U_{rt} - l^N_{rt} = \left[1 + \psi\xi_r\pi_{H,r}\right]^{-1} h^U_t, \tag{18}$$

and

$$l_{rt} = \lambda^U_r h^U_t + \psi\pi_{H,r}\left[w_{rt} - p_{rt}\right]. \tag{19}$$

Proof. See Appendix B.2. ■

Propositions 1 and 2 completely characterize the short- and long-run changes in relative wages and prices as functions of elasticities, shares, and the national-level change in the mass of unauthorized workers. They also characterize the full transition in an economy with no internal migration. The dynamics are characterized by equation (12), which describes the evolution of the capital-labor ratio in each region. To highlight the forces at work, the following corollaries describe the long run (at $t \to \infty$) and short-run (at $t = 1$) implications of these propositions.

Corollary 1 ***(The long run)*** *If the mass of unauthorized workers remains fixed after some period k, $h^U_t = h^U_{t-1} = h^U_\infty$ for $t > k$, then real wages converge to the pre-shock steady state level, $w_{rt} - p_{rt} = 0$ as $t \to \infty$.*

Proof. Evaluate (12) as $t \to \infty$, plugging in $h^U_t = h^U_{t-1} = h^U_\infty$ for $t > k$. ■

Corollary 1 states that in the long run aggregate real wages are invariant to h^U_∞. The intuition is that the economy is scale-free, and that following a deportation event capital gets decumulated until the capital-labor ratio returns to its pre-shock steady state level. This does not mean that the real wages of natives and immigrants do not change. The long run changes in aggregate and occupational real wages can be obtained by plugging equation (17) into (13) and (14):

$$w^N_{r\infty} - p_{r\infty} = \xi_r\lambda^U_r\xi^l_r h^U_\infty; \quad w^U_{r\infty} - p_{r\infty} = -\xi_r\lambda^N_r\xi^l_r h^U_\infty, \tag{20}$$

and

$$w^N_{ro\infty} - p_{r\infty} = \xi^N_{ro}\lambda^U_r\xi^l_r h^U_\infty; \quad w^U_{ro\infty} - p_{r\infty} = -\xi^U_{ro}\lambda^N_r\xi^l_r h^U_\infty. \tag{21}$$

Following a decline in the mass of undocumented households ($h^U_\infty < 0$), the long-run average real wages of natives $w^N_{r\infty} - p_{r\infty}$ decrease, while average real wages of immigrants $w^U_{r\infty} - p_{r\infty}$ increase in all regions. The intuition is that the relative supply of natives increases, reducing their wage.

However, real wages of natives can rise in certain occupations that are intensive in unauthorized workers ($\omega^N_{ro} = \frac{\lambda^U_{ro}}{\lambda^U_r} > 1$) provided the elasticity of substitution across worker types is sufficiently large (ϵ large relative to θ and $\bar{\eta}_r$, equation 14). Intuitively, if natives and immigrants are close enough substitutes, but occupations are not, then a decline in the mass of immigrants can increase the demand for natives in occupations that initially use a lot of foreign workers. Similarly, real wages of unauthorized immigrants could decline in some occupations intensive in native workers (when $\omega^U_{ro} = \frac{\lambda^N_{ro}}{\lambda^N_r} > 1$).

Finally, equation (15) implies

$$p_{rs\infty} - p_{r\infty} = \kappa_s \left[1 - \alpha_s\right] \xi^s_r \left[\lambda^U_r - \lambda^U_{rs}\right] \xi^I_r h^U_\infty,$$

i.e. relative prices will rise in sectors that use immigrant labor intensively ($\lambda^U_{rs} > \lambda^U_r$). The magnitude of the relative price effect is scaled by the share of value added in total output, κ_s.

Proposition 1 also highlights that the magnitudes of the wage and price changes depend on the composite elasticities defined in (16) and on the shares of unauthorized workers in the regional wage bills, λ^i_{ro}, λ^i_{rs}, and λ^i_r. If there is full specialization (natives and immigrants work in different occupations): $\lambda^N_{ro} = \pi^N_{ro} = 1$ and $\lambda^N_{ro'} = \pi^N_{ro'} = 0$ for $o' \neq o$, then $\omega_r = 0$, and $\xi_r = \xi^s_r = \xi^i_{ro} = \frac{1}{\bar{\eta}_r}$. In this case, the long-run elasticity of native real wages to a change in relative labor supplies equals the share of unauthorized workers in the wage bill divided by the aggregate elasticity of substitution across occupations. The long-run elasticity of relative sectoral prices $p_{rs\infty} - p_{rs'\infty}$ to relative labor supplies is given by the difference between the share of unauthorized workers in the sectors' wage bills ($\lambda^U_{rs} - \lambda^U_{rs'}$), times the labor share divided by the substitution elasticity across occupations, $\kappa_s \left[1 - \alpha_s\right] / \bar{\eta}_r$.

At the other extreme, if unauthorized immigrants are evenly spread across occupations ($\lambda^U_{ro} = \lambda^U_r$), then $\omega_r = \omega_{ro} = 1$ and $\xi_r = \xi^i_{ro} = \frac{1}{\epsilon}$: the long-run elasticity of native real wages to a change in relative labor supplies equals the initial share of unauthorized workers in the wage bill divided by the elasticity of substitution between immigrants and natives. Furthermore, if natives and immigrants are perfect substitutes ($\epsilon \to \infty$), removing immigrants has no impact on relative wages. Without differences in the native intensity across occupations ($\lambda^U_r = \lambda^U_{rs}$), there are no changes in relative sectoral prices in the long run: $p_{rs\infty} - p_{r\infty} = 0$.

Note that changes in long run relative prices in these limiting cases are independent of the value of the occupational supply elasticity θ. More generally, the composite macro elasticities ξ_r, ξ^s_r, and ξ^i_{ro} depend on weighted averages of the elasticities between workers types and occupations, ϵ and $\bar{\eta}_r$. In the special case where $\epsilon = \bar{\eta}_r$, then $\xi_r = \xi^s_r = \xi^i_{ro} = \frac{1}{\bar{\eta}_r}$, and the price changes are the same as in the full-specialization case and independent of θ. Finally, if workers cannot move across occupations ($\theta = 0$), $\xi^s_r \equiv \frac{1}{\bar{\eta}_r}$ and changes in relative prices are inversely proportional to the elasticity of substitution across occupations.

As we will discuss below, our assigned values for the elasticities ϵ, η, and θ imply that $\xi_r^s \simeq 1/2$. To take the most immigrant-intensive sector as an example, in Farms the labor share in gross output is about 0.2 according to our calibration ($\kappa_s [1-\alpha_s] \simeq 0.2$). The data reported in Figure 2 show that the share of unauthorized immigrants in the wage bill is about 0.24 larger in Farms than in the aggregate ($\lambda_r^U - \lambda_{rs}^U = -0.24$). Together these numbers indicate that if the relative supply undocumented workers falls by 50% in a region ($l_{rt}^U - l_{rt}^N \simeq \log(0.5)$), then relative Farm prices in the region rise by roughly 1.66% ($= \frac{1}{2} \times \frac{1}{5} \times 0.24 \times \ln(0.5)$). Thus, even a large change in relative supplies has a limited impact on the relative price of Farm output. As we will see in Section 4, this back of the envelope calculation yields price changes of similar magnitude to the results from the full quantitative model.

Finally, we evaluate the extent to which the endogenous response of the labor supply and internal migration margins mitigate the shock's impact on relative prices. First, note that without these margins, $\psi = \nu = 0$, then $\xi_r^l = 1$ and the changes in relative supplies are equal in all regions and equal to the shock, $l_{r\infty}^U - l_{r\infty}^N = h_\infty^U$ (equation 17). More generally, our calibration implies a range of ξ_r^l from 0.95 to 0.97, indicating that changes in relative labor supplies are close to $l_{r\infty}^U - l_{r\infty}^N \simeq h_\infty^U$ (equation 17) . To understand why, note first that abstracting from migration ($\nu = 0$), it becomes $\xi_r^l = [1 + \psi \xi_r \pi_{H,r}]^{-1}$. In the data, the labor force participation is about 70%, and in our calibration the relevant elasticities are $\psi \simeq 0.3$ and $\xi_r \simeq 0.5$. This yields a value of $\xi_r^l \simeq [1 + 0.3 \times 0.3 \times 0.5]^{-1} \simeq 0.96$, implying that changes in labor force participation have a muted effect on how deportations impact relative wages. Second, if $\psi = 0$, then $\xi_r^l = \left[1 + \nu \left[\pi_{M,r}\xi_r - \sum_{r'=1}^{\mathcal{R}-1} \pi_{rr'}\pi_{M,r'}\xi_{r'}\right]\right]^{-1}$. To understand this, note that the magnitude of the differential migration response into a region depends on the differential effect of the shock on real wages across regions. When $\xi_r = \xi$ does not vary by region, then $\xi^l = \left[1 - \nu \sum_{r'=1}^{\mathcal{R}-1} \left[\pi_{r'}^N - \pi_{r'}^U\right] \xi \lambda_{r'}^U\right]^{-1}$.

Given these results, the discussion that follows focuses on the special case without the labor force participation decision ($\psi = 0$) to facilitate the exposition. Appendix B.2 presents formulas for the general case $\psi > 0$. We now contrast the long-run results with the short run.

Corollary 2 ***(The short run)*** *The changes in average real wages at $t = 1$ are given by:*

$$w_{r1} - p_{r1} = -\alpha_r \lambda_r^U h_1^U. \tag{22}$$

Proof. Evaluate (12) at $t = 1$, and substitute equation (19). ■

Equation (22) shows that following a decline in the mass of undocumented households ($h_1^U < 0$), average regional real wages rise in proportion to the regional aggregate capital share α_r. This increase is driven by the rise in the capital-labor ratio, which prior to any adjustments in capital or migration is given by $\lambda_r^U \times h_1^U$. It is straightforward to combine (13), (18), and (22) to obtain the short-run changes in real wages for natives and immigrants:

$$w_{r1}^N - p_{r1} = [\xi_r - \alpha_r] \lambda_r^U h_1^U; \quad w_{r1}^U - p_{r1} = -\left[\xi_r \frac{\lambda_r^N}{\lambda_r^U} + \alpha_r\right] \lambda_r^U h_1^U.$$

The decline in the mass of undocumented households affects natives through two opposing mechanisms. On the one hand, as in the long run, natives become more abundant relative to immigrants, which lowers their wages in relation to average wages ($\xi_r > 0$ as shown in equation 13). On the other hand, in the short run labor also becomes more scarce relative to capital, which increases real wages (α_r in equation 22). The net effect depends on the relative strength of these two mechanisms. In our calibration (see below), $\xi_r \simeq 0.35$, whereas $\alpha_r \simeq 1/2$ on average for the US economy.[10] Under these values, real wages for natives increase in the short run. For immigrant workers, the two mechanisms – becoming a relatively scarcer type of labor and higher capital-labor ratio – go in the same direction and both contribute to an increase in real wage. Note that while the higher capital-labor ratio effect has the same magnitude for the natives and immigrants, the relative labor supply effect is much stronger for the immigrants, as $\frac{\lambda_r^N}{\lambda_r^U} >> 1$ in every region in the data (see Figure 1).

Following a similar logic, we can obtain the short-run changes in occupation-specific real wage changes:

$$w_{ro1}^N - p_{r1} = \left[\xi_{ro}^N - \alpha_r\right] \lambda_r^U h_1^U; \quad w_{ro1}^U - p_{r1} = -\left[\xi_{ro}^U \frac{\lambda_r^N}{\lambda_r^U} + \alpha_r\right] \lambda_r^U h_1^U.$$

The short run change in occupation-specific real wage is affected similarly by the two mechanisms explained above. Note, however, that the impact of deportations on occupation-specific real wages is ambiguous, since ξ_{ro}^N can be negative as highlighted above. Finally, equation (15) implies that the short run change in relative prices is

$$p_{rs1} - p_{r1} = \kappa_s \left[\left[1-\alpha_s\right] \xi_r^s \left[\lambda_r^U - \lambda_{rs}^U\right] + \left[\alpha_s - \alpha_r\right] \lambda_r^U\right] h_1^U. \tag{23}$$

The decline in the mass of undocumented households has 2 effects on relative prices. The first, encapsulated by $[1-\alpha_s]\, \xi_r^s \left[\lambda_r^U - \lambda_{rs}^U\right]$, is due to differences in the sectoral wage bill share of undocumented workers and implies that relative prices in immigrant-intensive sectors ($\lambda_{rs}^U > \lambda_r^U$) will rise following deportations. This effect also operates in the long run. The second effect, captured by $[\alpha_s - \alpha_r]\, \lambda_r^U$, reflects changes in the capital-labor ratios. As capital becomes more abundant relative to labor, the relative prices of capital-intensive goods ($\alpha_s > \alpha_r$) fall.

4 Quantitative results

This section presents our main quantitative exercises. We follow the approach developed by Dekle, Eaton, and Kortum (2008) and express the model in Section 3 in gross proportional changes. Appendix C.1 lists the system of equations that characterizes how relative prices and output respond to exogenous changes in the mass of unauthorized workers, as a function of the model's

[10] We calibrate the α_s's to match the employee compensation and value added data in the BEA Input-Output accounts. It is a well-known feature of these data that they imply a labor share of about 0.5, as they do not make the adjustment for the labor wage component of the income of the self-employed.

elasticities and observable shares.

4.1 Calibration

To solve the equilibrium system in Appendix C.1, we need to assign values to the initial shares s_{rs}, ϕ_{rso}, λ^i_{ro}, π^i_{ro}, $\pi^i_{M,r}$, π^i_r α_s, κ_s, and $\gamma_{ss'}$ defined in Section 3.[11] With trade across regions, we also need bilateral sectoral export and absorption shares, $\varpi^x_{rr's} \equiv \frac{P^y_{rs} Y_{rr's}}{P^y_{rs} Y_{rs}}$ and $\varpi_{r'rs} \equiv \frac{P^y_{r's} Y_{r'rs}}{P_{rs} X_{rs}}$. To compute aggregate and household-specific price indices, we need aggregate consumption expenditure shares γ_s and any household-type-specific shares $\gamma_s(h)$. Finally, we need to assign values to the elasticities η, ϵ, and θ discussed in Section 3.6, along with the elasticity between the authorized and unauthorized σ, the elasticity of substitution across goods produced in different locations χ, and the elasticities governing the migration and labor force participation decisions, ν and ψ. Here, we briefly describe how we assign values to these shares and elasticities. Table 1 summarizes the calibration. Appendix A.2 contains further details.

4.1.1 Shares

We implement the model on $\mathcal{S} = 44$ sectors based on the NAICS classification, $\mathcal{O} = 36$ Census occupations, and $\mathcal{R} = 48$ regions roughly corresponding to 47 US states and the rest of the world.[12] Appendix Table A1 lists the occupations. Appendix Table A2 lists the sectors, along with their NAICS 3-digit numbers. We compute all the wage bill shares s_{rs}, ϕ_{rso}, λ^i_{ro}, π^i_{ro}, $\pi^i_{M,r}$, and π^i_r directly from the ACS data described in Section 2. Cost shares α_s, κ_s, and $\gamma_{ss'}$, and expenditure shares γ_s are sourced from the BEA Input-Output matrix Make and Use Tables for 2023. These tables are combined to construct an industry-by-industry use table, from which the production function parameters and final expenditure shares can be computed. In case of the labor shares, we set them to harmonize the national output shares in the BEA IO matrix with the wage bill shares in the ACS, as described in Appendix A.2.3.

International and intra-national trade shares, $\varpi_{rr's}$ and $\varpi^x_{rr's}$, are built in successive steps by combining the Commodity Flow Survey (CFS) data for intra-US trade for a subset of sectors; US Census data for state-level sectoral imports and exports; BEA data for state-level sectoral GDP and PCE; the BEA IO table information on US-wide domestic sales, imports, and exports; and OECD ICIO data for international trade by sector between the US and the rest of the world. The procedure broadly follows Caliendo, Dvorkin, and Parro (2019) and Rodríguez-Clare, Ulate, and Vasquez (2025), and is described in detail in Appendix A.2. An important aspect of the procedure is that the only direct information on internal trade between the US states is the CFS, which contains only a subset of sectors (essentially manufacturing and some but not all mining). We

[11] With these values, we can construct the remaining shares entering Proposition 1 as $s_{ro} = \sum_s \phi_{rso} s_{rs}$, $\lambda^i_{rs} = \sum_o \lambda^i_{ro} \phi_{rso}$ and $\lambda^i_r = \sum_s \lambda^i_{rs} s_{rs}$.

[12] We merge a few small states together: Delaware-New Jersey, DC-Maryland, Alaska-Hawaii and New Hampshire-Vermont.

proceed by first using the information from Barkai and Karger (2020) to classify sectors not covered by CFS into tradeable and non-tradeable. For the non-tradeable sectors, sectoral production is equal to sectoral purchases in each region by assumption. For the tradeable sectors, we use geographic variables, coefficients from gravity regressions, and adding-up constraints to populate the intra-national trade matrix following Rodríguez-Clare, Ulate, and Vasquez (2025).

4.1.2 Elasticities

We take the values for the elasticities from the existing literature. The elasticity of substitution between occupations is sourced from Burstein et al. (2020) and set to $\eta = 1.6$. The elasticity of substitution between natives and immigrants is set to $\epsilon = 3$. While the earliest studies had put this elasticity in the 10-20 range, more recent estimates yield much lower values. For instance Burstein et al. (2020) report an estimate of 4.6, while Clemens and Lewis (2024), using a randomized experiment, estimate a value of 1.3. We select 3, as roughly the midpoint between these two recent estimates, and evaluate robustness to higher and lower values. There are few available estimates of the elasticity of substitution between authorized and unauthorized immigrants. Borjas and Cassidy (2019) estimate an aggregate elasticity of 14, as an average of men's and women's elasticities. With this in mind we set $\sigma = 14$, although we note that in our framework σ is an elasticity within occupations.

For the labor supply elasticities, we set $\theta = 1$ to match the elasticity of supply to an occupation as a function of relative wages as estimated by Burstein, Morales, and Vogel (2019). Note that, in combination with the parameters discussed above, the implied values for the composite elasticities governing real wage and relative price changes are roughly $\zeta_r \simeq 0.35$ and $\xi_r^s \simeq 0.5$.

We set the long-run elasticity of worker flows to real income differentials to $\nu = 1.5$ following Fajgelbaum et al. (2019). The parameter ψ governs the elasticity of the labor force participation with respect to the real expected wage, $\frac{d \ln \pi^i_{M,r}}{d \ln \frac{W^i_r}{P_r}} = \psi \left[1 - \pi^i_{M,r}\right]$. In the data, labor force participation is about 70% ($\pi^i_{M,r} = 0.7$). In a meta-analysis of existing studies in the literature, Chetty et al. (2011) report an average "extensive" margin elasticity of 0.2. Combining these two pieces of information yields $\psi = 0.3$. We set the elasticity of substitution between goods produced in different locations to χ =2 following Boehm, Levchenko, and Pandalai-Nayar (2023). Finally, we set the period length to a year. The discount rate, $\beta = 0.95$ and the capital depreciation rate, $\delta = 0.05$, are calibrated to to values conventional in the literature (see e.g. Kleinman, Liu, and Redding, 2023).

4.2 The economic impact of removing unauthorized workers

This section reports the impact of removing 50% of the unauthorized population from the US, $\hat{H}^U = 0.5$. This reduction amounts to a deportation of about 3.7 million workers, which is roughly commensurate with the DHS stated target of removing 1 million people per year between 2025 and 2028 (Department of Homeland Security, 2025b).

Table 1: Calibration

	Description	Value	Source
Elasticities			
η	Cross-occupation	1.6	Burstein et al. (2020)
ϵ	Native-foreign immigrants	3	Clemens and Lewis (2024)
σ	Authorized-unauthorized	14	Borjas and Cassidy (2019)
θ	Occupation-specific labor supply	1	Burstein, Morales, and Vogel (2019)
ν	Migration	1.5	Fajgelbaum et al. (2019)
ψ	Labor market participation	0.3	Chetty et al. (2011)
χ	Armington	2	Boehm, Levchenko, and Pandalai-Nayar (2023)
β	discount rate	0.95	Kleinman, Liu, and Redding (2023)
δ	depreciation rate	0.05	Kleinman, Liu, and Redding (2023)
Shares			
$\{\alpha_s, \kappa_s\}$	Factor and intermediate input shares		ACS + BEA IO table
$\{\gamma_s\}$	Aggregate final shares		BEA IO table
$\{\gamma_{s's}\}$	Intermediate input shares		BEA IO table
$\{s_{rs}\}$	Share of sector s in regional wage bill		ACS
$\{\phi_{rso}\}$	Share of occupation o in sector s region r wage bill		ACS
$\{\lambda^i_{ro}\}$	Share of type i worker in occupation o region r wage bill		ACS
$\left\{\pi^i_{M,r}\right\}$	Share of type i workers in the formal labor market		ACS
$\{\pi^i_r\}$	Share of type i workers in region r		ACS
$\{\varpi_{rr's}\}$	Share of sector s region r purchases accounted for by region r'		CFS, BEA IO table and ACS
$\{\varpi^x_{rr's}\}$	Share of sector s region r sales accounted for by region r'		CFS, BEA IO table and ACS

Note: This table summarizes the calibration of model elasticities and shares.

4.2.1 Real wages

Regional wages: We start by computing the change in average, group-specific, real wages across regions. Panel A of Figure 4 displays the natives' real wage changes, $\Delta \ln \left(W_{rt}^{N} / P_{rt} \right)$, plotted against the initial share of unauthorized workers in the aggregate wage bill in each region, λ_r^U. The left panel shows changes at $t = 1$ (the short run), while the right panel plots changes as $t \to \infty$ (the long run). In both plots, the horizontal line displays the national average.[13]

Natives' real wages increase in all but 3 states in the short run, averaging 0.15% nationally. The size of the increase is larger in states with relatively more unauthorized immigrants. By contrast, native real wages decline in every state in the long run, averaging -0.33% nationally. Again, the fall is larger in states with more unauthorized immigrants. The analytics in Section 3.6 help understand these results. Removing unauthorized workers initially increases the capital labor ratio, while also making natives the relatively more abundant type of labor. As discussed in Section 3.6, the first effect bids up native wages, and dominates in the short run under our parameterization. The second effect bids down native wages, and is the only one operating in the long run as the capital-labor ratio returns to its pre-shock level.

Note that both effects are stronger in states with higher initial migrant shares. Thus, those states experience the largest absolute changes in wages in both the short and the long run.[14] The largest natives' long-run real wage reductions are in California, Washington, Delaware-New Jersey, and Texas, ranging from -0.38% to -0.49%. In the states where natives' real wages fall the least – North Dakota, Maine, South Dakota, and Michigan – the changes are around -0.2%. Given that our calibration implies an elasticity of $\xi_r \simeq 0.35$, and that $\Delta \ln H^U = \ln(0.5) = -0.69$, the national real wage reduction of -0.33% is in line with the approximation provided by Proposition 1 for the simplified model. Figure 5 visualizes the transition path for the real wage change for the US as a whole and two states: California and Maine (one of the states with the lowest unauthorized shares). The California time path is steeper than the national average: it starts with a larger short-run increase, but ends up with a lower long-run wage. The opposite is true for Maine, whose time path is flatter than the national one. Note that Maine experiences a small uptick in wages between the first and second periods. This is due to our assumption that migration decisions occur at the end of the period, so at $t = 1$ deportations happen but the rest of the US population did not yet have a chance to adjust. Starting at $t = 2$ out-migration from Maine makes labor more scarce there and pushes up real wages.

Panels B and C of Figure 4 plot the aggregate log wage changes for foreign immigrants in the short and the long run, $\Delta \ln \left(W_{rt}^{i} / P_{rt} \right)$, $i = A, U$ against the initial share of unauthorized workers

[13] Throughout this section, we compute 'average' real wages as the group-specific wage index W_{rt}^i deflated by the average regional price index P_{rt}. Below we discuss differences in price indices across households consuming different baskets, $P_{rt}(h)$. The national aggregate real wage change is defined as $\Delta \ln \left(W_t^i / P_t \right)$, where the national nominal wage change $\Delta \ln W_t^i$ is the regional wagebill-share-weighted log change in the regional wages W_{rt}^i, and the national price index change $\Delta \ln P_t$ is the regional expenditure-weighted log change in regional P_{rt}.

[14] The fit is not perfect because in the full model the wage response also depends on the relative shares of authorized vs. unauthorized immigrants.

in the immigrant wage bill in each region, $\lambda_r^U / \left[\lambda_r^A + \lambda_r^U\right]$. As discussed in Section 3.6, foreign immigrants benefit in every state, and in both the short and the long run. This is due to the fact that immigrants become scarcer relative to both capital and native workers, with both effects boosting immigrant wages. Although short-run gains are larger, the relative labor scarcity effect dominates quantitatively. Real wages for the authorized workers rise by 3.7% in the short run, and by 3.21% in the long run on average at the national level. In the long run they range from 0.70% and 1.65% in Montana and North Dakota to 3.88% and 4.53% in Nevada and Idaho. The largest gains by far are for the unauthorized workers that remain in the US, whose real wages increase on average by 12.89% in the short run and 12.24% in the long run, ranging from 8.55% in Massachusetts to 24.19% in North Dakota in the long run.

Occupation-specific wages: As noted in Proposition 1, the short-run increase in the capital-labor ratio raises wages uniformly across occupations. We thus focus our discussion on the long run changes. The short run wages, which are an upward parallel shift compared to the long run changes, are relegated to Appendix Figure A1.

Figure 6 reports long-run changes in average, group-specific real wages across occupations. The left panels report national averages, with the x-axis sorted by the share of unauthorized in the nationwide wage bill of that occupation.[15] As anticipated by Proposition 1, real wages for natives rise in a few occupations that are very intensive in foreign immigrants. The largest increases are in Farming, Fishing, and Forestry occupations (3.44%), followed by Construction: Roof, Steel (0.86%). The right panel shows long-run real wage changes by occupation-region pair, $\Delta \ln \left(W_{rot}^i / P_{rt}\right)$.[16] In line with the Proposition, real wage changes are larger in occupation-regions with a high presence of foreign unauthorized workers. The increase in Farming and Forestry real wages exceed 5% in a number of states, and reach 7.17%, 6.69% and 6.55% in California, South Carolina, and Oregon. The figure also shows small declines in long-run real wages in 23 out of 36 occupations. Across these occupations the weighted average decline in national real wages is -0.38%. The worst-affected occupations are Other Personal Services, Health, Social and Media, and Business, Finance, and Legal.

In contrast, nationwide real wages for authorized and unauthorized immigrants that remain in the US rise in all occupations due to their high substitutability with the removed workers (middle and bottom left panels). These gains increase with the initial share of unauthorized immigrants in the immigrant wage bill (middle and bottom right panels). The largest gains for foreign authorized workers are in Farming and in Construction: Roof, Steel (15.61% and 8.55% at the national level). Unauthorized foreign workers remaining in the US see even larger gains, of 23.49% in Farming and 17.34% in Construction: Roof, Steel. For both types of immigrant workers, the smallest gains are in occupations such as Business, Finance, and Legal, Other Personal Services, Health, and

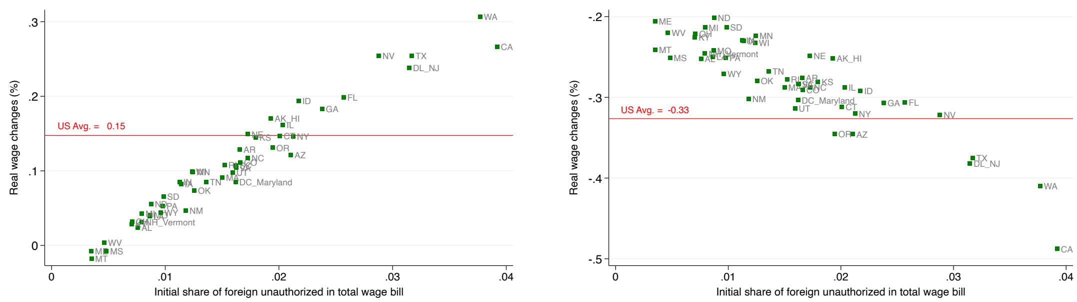
[15] The national occupational real wage change is defined as $\Delta \ln \left(W_{ot}^i / P_t\right)$, where the national occupational nominal wage change $\Delta \ln W_{ot}^i$ is the within-occupation wagebill-share-weighted log change in the occupation-region wages W_{rot}^i, and the national price index change $\Delta \ln P_t$ is defined in footnote 13.

[16] The panel labels 12 broad occupational categories, though each of the 36 occupations is plotted separately.

Figure 4: Real wages in the short and long run

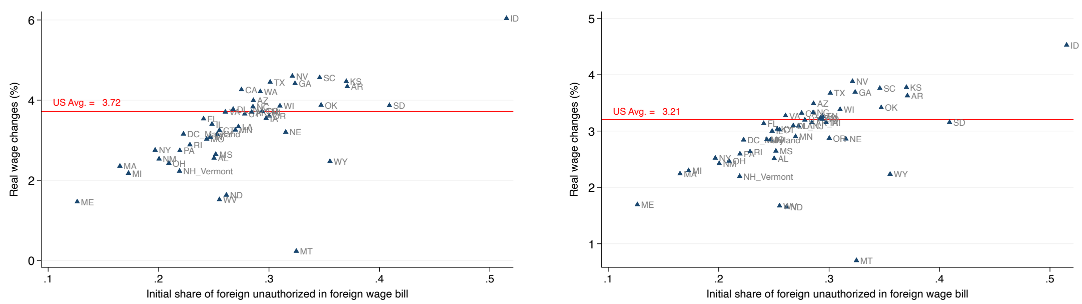
Panel A: Natives

Short run | Long run



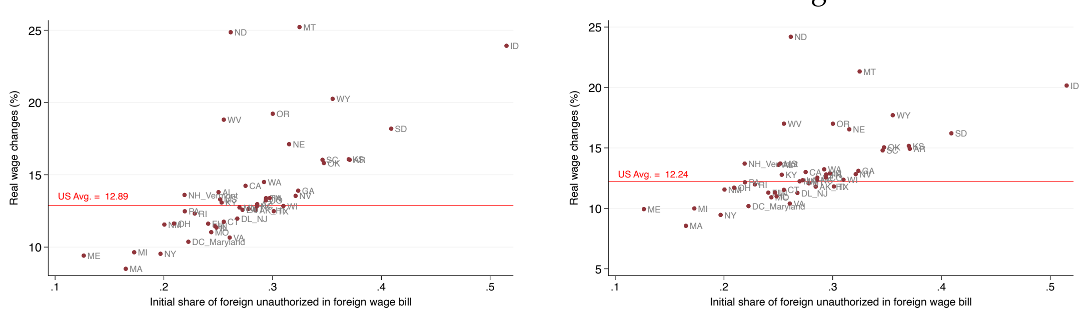
Panel B: Foreign Authorized

Short run | Long run



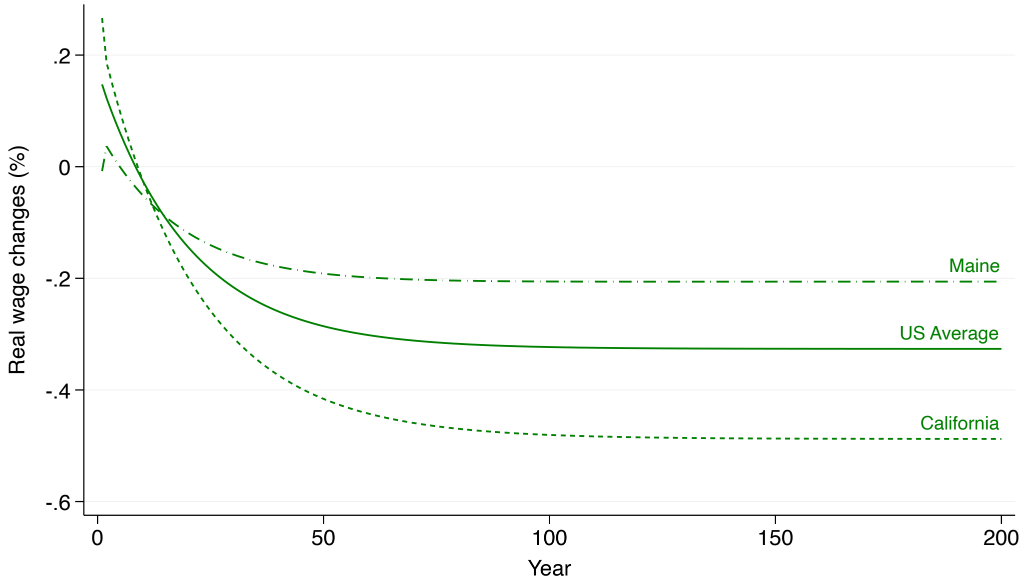
Panel C: Foreign Unauthorized

Short run | Long run



Notes: This figure plots the real wage changes, for each region, following a 50% reduction in unauthorized workers nationally. Panels A, B, and C plot the results for natives, foreign authorized, and foreign unauthorized, respectively. The left panels display the short-run change, the right panel the long-run change.

Figure 5: Native real wages: the transition



Notes: This figure plots the native real wage changes in the transition to the new steady state, for the US as a whole, California, and Maine.

Social and Media, where the foreign worker presence before the shock is minimal.

4.2.2 Relative prices

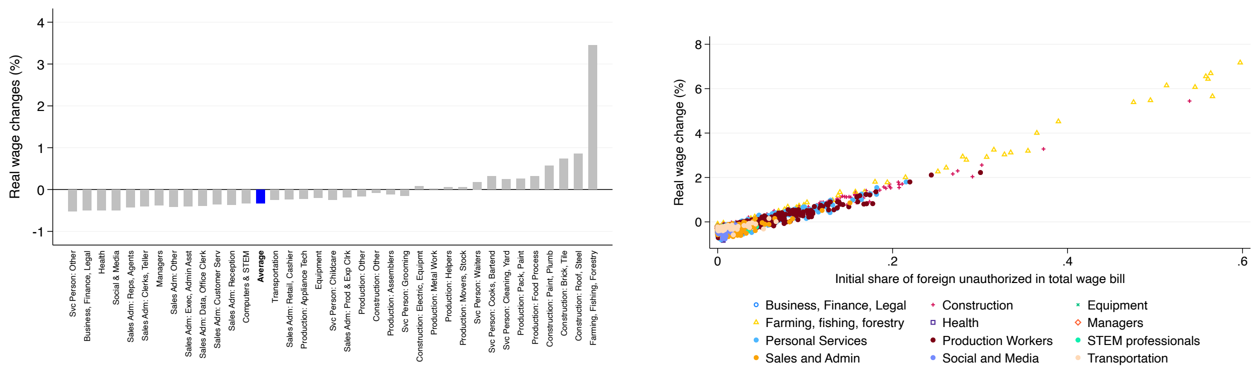
Sectoral prices: Panel A of Figure 7 plots the national changes in relative producer prices by sector, for both the short run and the long run, $\Delta \ln \left(P^{y}_{rst}/P_{rt}\right)$.[17] Removing unauthorized immigrants makes Farms and Forestry and Fishing more expensive relative to the average consumption basket, by 1.64% and 1.42% respectively at the national level in the long run. This is in line with the prediction of Proposition 1 given our calibrated value of $\zeta^{s}_{r} \simeq 1/2$. In the rest of the sectors the long-run relative price changes are small on average, though for a few, such as Construction and Food and Beverages Manufacturing, the relative price increases reach 0.8-0.9% in some regions. These sectors exhibit similar price changes in the long run and the short run.

In the short run, Real Estate prices fall by about -0.35% in relative terms. Real Estate is predominantly capital. As capital becomes relatively abundant, Real Estate becomes cheaper. At the extreme, in the short run Real Estate prices fall by more than 0.5% in California. The change in producer prices is highly heterogeneous across locations, in a way that is well-predicted by the pre-shock unauthorized share in the region-sector wage bill (Panel B). California, which is the

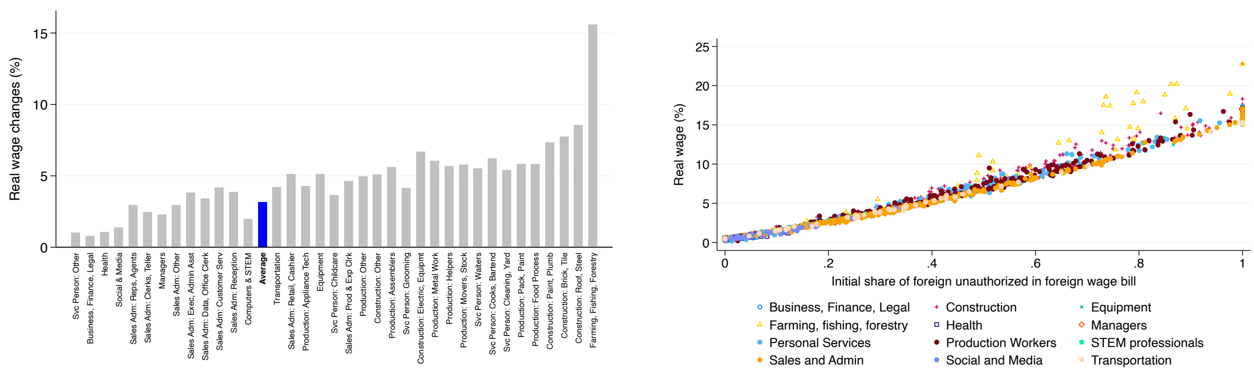
[17] The national sectoral relative producer price change is defined as $\Delta \ln \left(P^{y}_{st}/P_{t}\right)$, where the national producer price change $\Delta \ln P^{y}_{st}$ is the sector-specific regional sales-share-weighted log change in the regional producer prices P^{y}_{rst}, and and the national price index change $\Delta \ln P_{t}$ as defined in footnote 13. Below, the national sectoral relative consumer price change is defined as $\Delta \ln \left(P_{st}/P_{t}\right)$, where $\Delta \ln P_{st}$ is the sector-specific regional expenditure-share-weighted log change in the regional consumer prices P_{rst}.

Figure 6: Changes in real wages across occupations, the long run

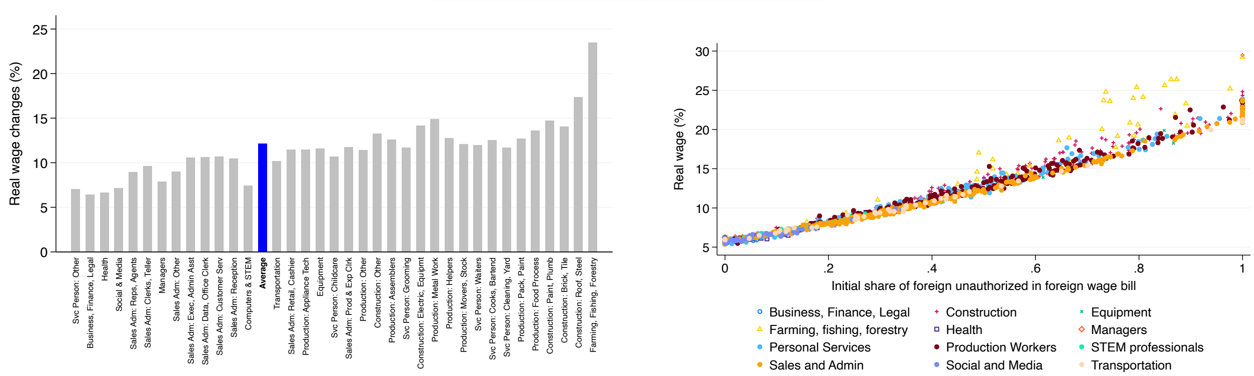
Panel A: Natives



Panel B: Foreign Authorized



Panel C: Foreign Unauthorized



Notes: This figure plots the long-run real wage changes of three types of workers, for each occupation, following a 50% reduction in unauthorized workers nationally. The left panels plot the nationwide changes, and the right panels plot the occupation-region changes against the share of foreign unauthorized workers in the total wage bill (top panel) or the share of unauthorized workers in the foreign wage bill (middle and bottom). For the bar graphs, occupations are sorted by the initial share of foreign unauthorized.

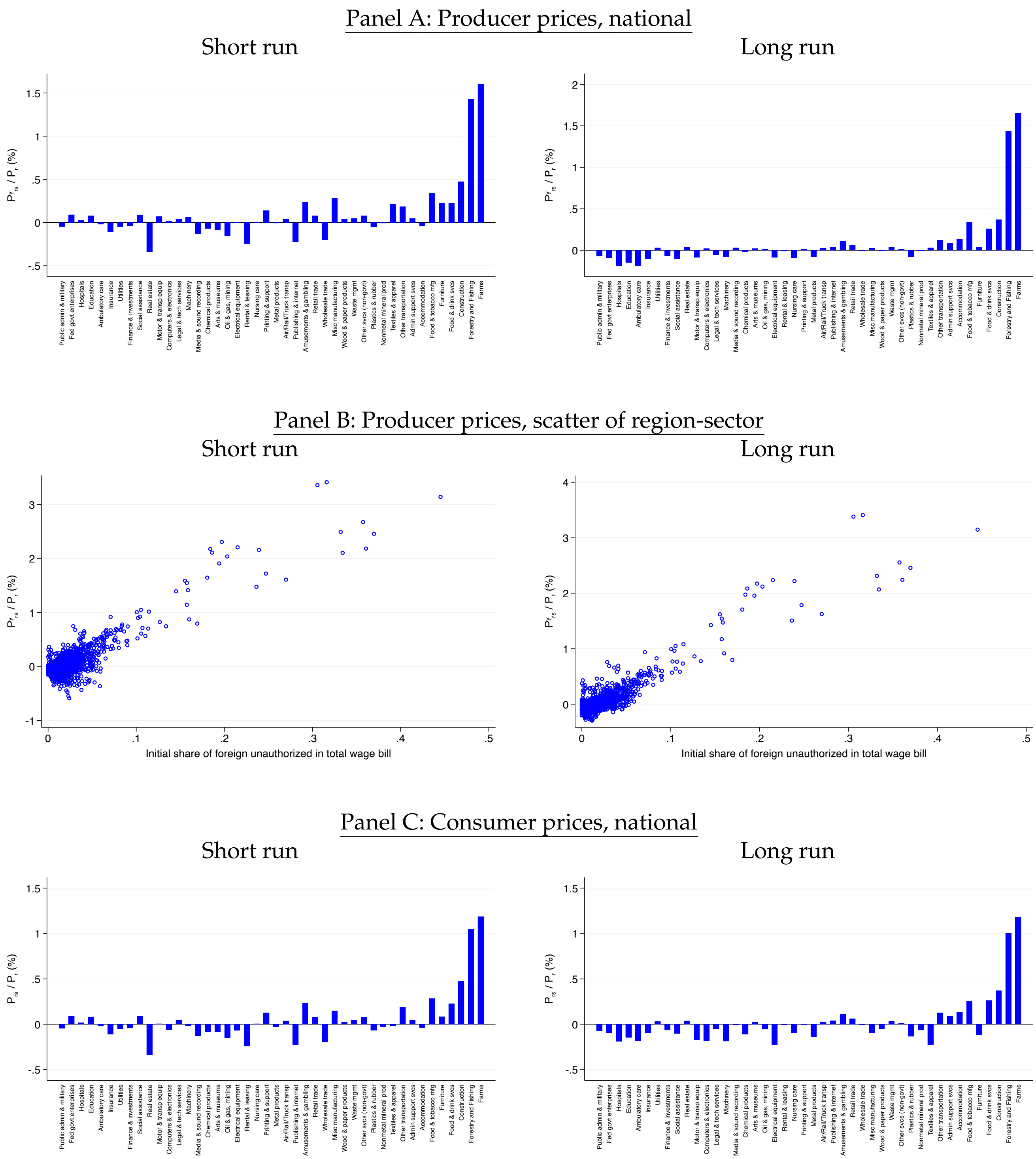
largest producer of both Farm and Forestry and Fishing products, sees producer price increases of 3.15% and 3.38% in those two sectors, respectively.

Panel C of Figure 7 plots the national changes in relative consumer prices by sector, $d \ln (P_{rst}/P_{rt})$. Changes in sectoral consumer and producer prices are similar at the national level, with long-run relative consumer price increases in Farming and Forestry and Fishing of 1.17% and 1.00%, respectively. Most other sectors exhibit negligible national average consumer price changes, of between -0.23% and 0.37% in the long run. The regional variation in consumer prices is more muted compared to producer prices. In the presence of international trade, consumer prices are weighted averages of region-specific producer prices. In addition, trade allows production to shift towards less affected regions. Thus, the increase in the long-run relative consumer prices of Farms and Forestry and Fishing in California are only 3.01% and 2.57%, respectively. Figure 8 reports the changes in sectoral output. Predictably, nationwide real output in all sectors declines, as now the US is a smaller country. In the long run, the declines in most sectors are on the order of 1%, with outliers being Farms and Forestry and Fishing, with declines of over 3%. The output declines are notably smaller in the short run, when the economy operates with the pre-shock capital stock, which is higher than in the long run.

Regional and income-specific consumption baskets: Figure 9 plots the change in $\Delta \ln (P_{rt}/P_t)$ against the initial presence of unauthorized immigrants. In the long run, the states with larger unauthorized presence such as California, Washington, Texas, and Delaware-New Jersey experienced larger increases in the overall price index $\Delta \ln P_{rt}$, at 0.2-0.3% above national CPI. By contrast, the states without many unauthorized immigrants saw CPI changes 0.3-0.4% below the national change. This positive slope is attenuated in the short run. The states with the highest initial presence of unauthorized see higher labor costs in both the short and the long run, as workers are removed. However, those states also experience the largest increase in the capital-labor ratio in the short run, which acts to push down consumption prices, all else equal. In the short run, the regions with the most unauthorized workers, California and Washington State, do not experience exceptional CPI changes relative to the national average.

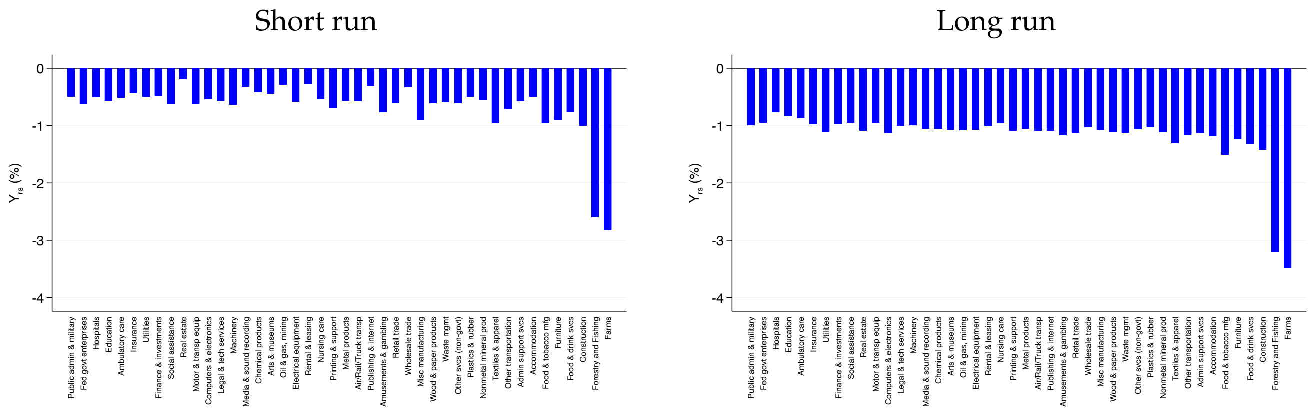
Finally, we compute the variation in consumption price indices across households of different incomes. Recall that in our framework, each household receives idiosyncratic preference shocks $\gamma_{st}(h)$, thus household consumption baskets differ and are reflected in household-specific price indices $p_{rt}(h)$. We thus use the US Consumer Expenditure Survey to compute expenditure shares $\gamma_{st}(h)$ for each 5% bin ("ventile") of the income distribution. Appendix Figure A2 displays the heterogeneity in consumption expenditure shares across 5% bins of the income distribution. Broadly, as income increases, expenditure shares on services rise, and expenditure shares on food fall. We then compute ventile-region-specific price indices $p_{rt}(h)$, $h \in \{0-5\%, 5-10\%, \ldots, 95-100\%\}$ using ventile-specific expenditure shares and regional consumer price changes $d \ln P_{rst}$. Figure 10 displays the scatterplot of the change in the price index of the top 5% of the income distribution against the price index of households in the bottom 5%, along with the 45-degree line. (These

Figure 7: Changes in relative sectoral prices



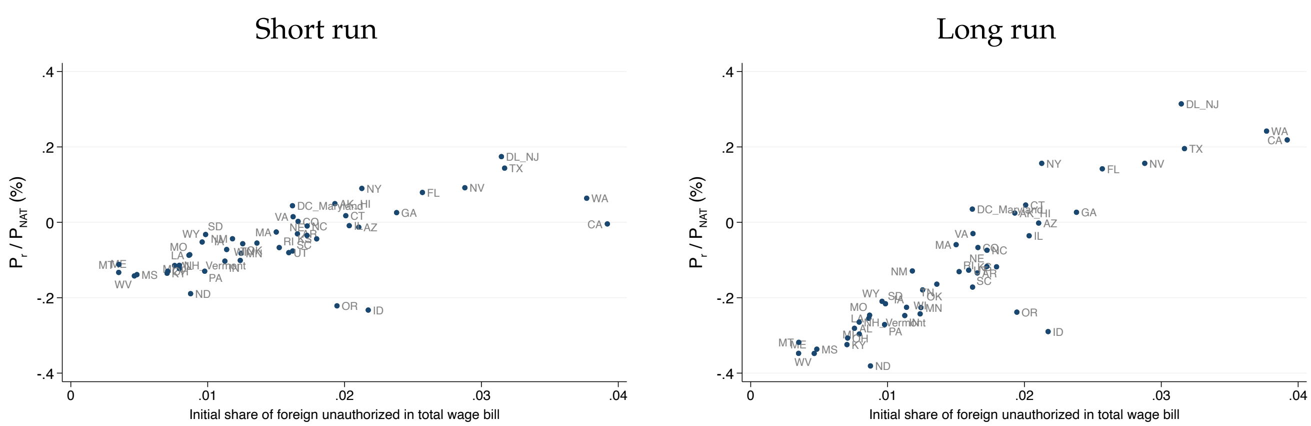
Notes: This figure plots the relative producer and consumer price changes by sector, following a 50% reduction in unauthorized workers nationally. The left panels plot the short-run changes, and the right panels the long-run changes. Panels A and C plot the national average changes in producer and consumer prices, respectively. Panel B reports scatterplots of region-sector producer price changes against the initial share of foreign unauthorized in the region-sector total wage bill.

Figure 8: Changes in sectoral output



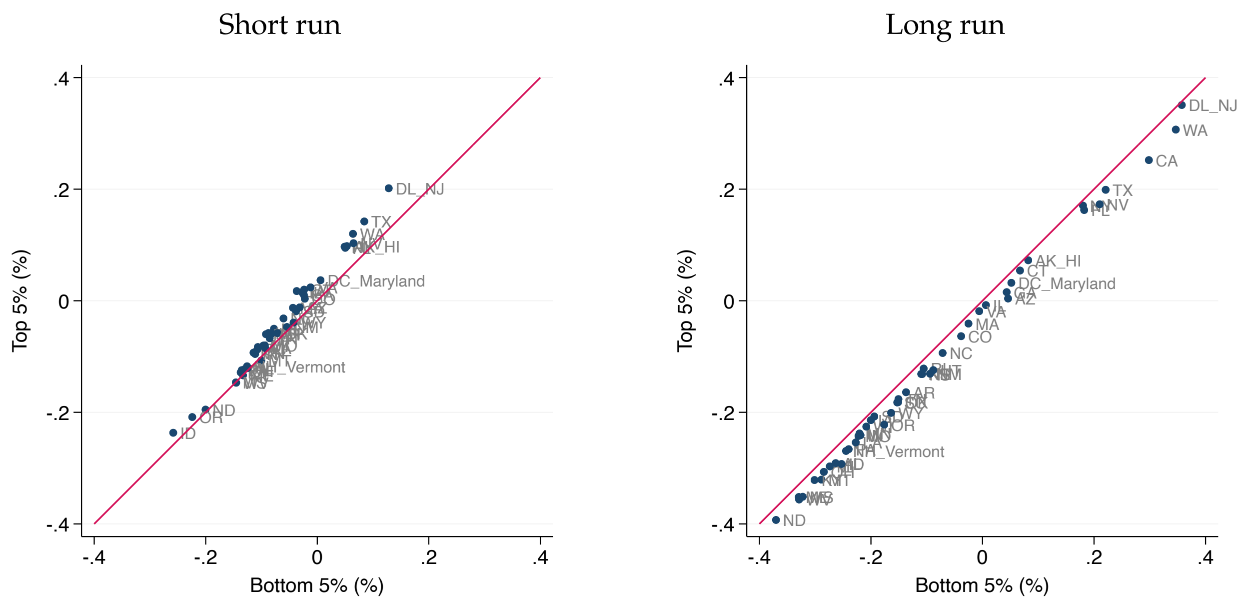
Notes: This figure plots the changes in real output, following a 50% reduction in unauthorized workers nationally. The left panel plots the short-run changes, and the right panel the long-run changes.

Figure 9: Consumption price index and initial presence of unauthorized workers



Notes: This figure plots the change in CPI relative to the nationwide CPI change (P_{rt} / P_t) against the initial statewide share of unauthorized workers in total employment, following a 50% reduction in unauthorized workers nationally. The left panel plots the short-run changes, and the right panel the long-run changes.

Figure 10: Consumption price index of the top 5% and bottom 5% of the income distribution



Notes: This figure plots the change in CPI ($p_{rt}(h)/P_t$) for the top 5% of the income distribution against the bottom 5% of the income distribution, following a 50% reduction in unauthorized workers nationally, along with the 45-degree line. The left panel plots the short-run changes, and the right panel the long-run changes.

changes are monotonic across income quantiles, with the price indices for middle quantiles in-between these two.) Qualitatively, the results differ between the short and the long run. In the long run, the cost of living for the high-income households rose by less with the removal of immigrants (the dots are below the 45-degree line). Thus, in the long run the migrant removal is regressive when it comes to the cost of living. By contrast, in the short run the cost of living of the high-income consumers rises by more than that of the poor. However, the differences across households of different incomes are quite minor quantitatively in both the short and the long run. On average across states, it amounts to 0.02% in the long run.

Sensitivity We discuss sensitivity of the results to the parameter values by means of reporting alternative elasticities ξ_r, ξ_r^s, ξ_{ro}^N, and ξ_r^l. (The analytical expressions in Propositions 1 and 2 provide a good approximation to the wage and price changes in the full quantitative model. Thus, assessing the sensitivity of the composite elasticities in the analytical formulas is a streamlined way of quantifying the role of the structural parameters.) Table 2 reports the results. Because the Farming occupations have the highest unauthorized share, we report ξ_{ro}^N for $o =$ Farming. This is the occupation that is most susceptible to changes in the unauthorized presence. The bold values are our baseline (recall that our baseline elasticities are $\theta = 1$, $\bar{\eta}_r = 1.6$, $\epsilon = 3$, $\nu = 1.5$, and $\psi = 0.3$). The three sub-panels at the top vary θ, while the $\bar{\eta}_r$ and ϵ are varied within each sub-panel. For ϵ, the range is between the 4.6 estimate of Burstein et al. (2020) and 1.3 of Clemens and Lewis (2024).

We consider the lower bound for the occupation macro elasticity to be 1.3 in order to coincide with the lower bound for ϵ, because in the special case of $\bar{\eta}_r = \epsilon$, the elasticity formulas simplify.

Comparing across the top 3 sub-panels, the value of θ does not matter quantitatively for ξ_r, and matters somewhat for ξ_r^s: higher values of θ make sectoral prices less sensitive to sectoral immigrant shares. This is sensible, as θ regulates mobility across occupations. Higher mobility means that migrants are more easily replaced by other workers, reducing the sensitivity of prices to the loss of migrant workers in a sector. At the same time, higher θ also makes Farming-specific native wages less sensitive to the shock. This is intuitive, as a higher θ implies an easier time for natives to enter the Farming occupation.

Going along the rows of the sub-panels reveals sensitivity to the aggregate occupational elasticity $\bar{\eta}_r$. Once again, ξ_r is not sensitive to the value of $\bar{\eta}_r$, while ξ_r^s is somewhat more sensitive: under the baseline values of other parameters, ξ_r^s ranges from 0.33 for $\bar{\eta}_r = 3$ to 0.59 for $\bar{\eta}_r = 1.3$. Finally, comparison of the the middle three columns of Table 2 reveals the sensitivity to ϵ. Lower ϵ makes average wages (ξ_r) and sectoral prices (ξ_r^s) more responsive than the baseline, though the effect is somewhat muted in case of ξ_r^s.

The key sensitivity turns out to be the Farming occupational wage. Here, the sign of the effect depends on the values of both $\bar{\eta}_r$ and ϵ. Recall that our baseline analysis, reported in bold in the middle row, found that Farming occupation native wages rose following the deportation shock ($\xi_{ro}^N < 0$ for $o =$ Farming). For a high value of $\bar{\eta}_r$, the sign reverses and the Farming wages actually fall following mass deportations. This is intuitive: when occupations are close substitutes, the Farming sector can more easily make up for the shortfall of Farming occupational labor with other occupations, obviating the need to bid up the wages of native Farming workers. Also, when ϵ is low – natives and immigrants are less substitutable – the sign also flips, thus once again following deportation native Farming wages fall. While these results are stated here in terms of the sign of the composite elasticity, we confirmed it in the full quantitative analysis. Thus, the sign of the occupation-specific native wage predictions is elasticity-dependent and should be treated with caution. Farming was one of the few places in which wages of natives benefited from removal of immigrants. Higher $\bar{\eta}_r$ or lower ϵ make the model predictions regarding Farming wages more in line with the economy-wide predictions of lower native wages in the long run.

The bottom panel evaluates the sensitivity of the regional labor supply ξ_r^l to the relevant parameters, namely the migration elasticity ν and the labor supply elasticity ψ. Here the bottom line is that even over fairly large ranges of ν and ψ, the elasticity of regional labor to the nationwide shock to migrant presence is quite close to 1. Thus, precise assumptions on how agents choose location and market labor supply matter little in this context. The functional form for ξ_r^l in Proposition 2 reveals the reasons behind the low sensitivity. The labor supply elasticity matters because labor supply responds to wages. Thus, in the expression for ξ_r^l, ψ is pre-multiplied by $\xi_r \pi_{H,r}$, which translate the migration shock to the wage change. Both of these are fractions, attenuating the impact of the labor supply elasticity on ξ_r^l. The migration elasticity matters for ξ_r^l insofar as the wage elasticity to the labor supply shock varies across regions: $\xi_r - \sum_{r'=1}^{\mathcal{R}-1} \pi_{rr'} \xi_{r'} \neq 0$. This

Table 2: Sensitivity

$\theta = 0$	$\bar{\eta}_r = 1.3$			$\bar{\eta}_r = 1.6$			$\bar{\eta}_r = 3$		
	ξ_r	ξ_r^s	ξ_{rF}^N	ξ_r	ξ_r^s	ξ_{rF}^N	ξ_r	ξ_r^s	ξ_{rF}^N
$\epsilon = 1.3$	0.77	0.77	0.77	0.76	0.63	1.50	0.73	0.33	2.99
$\epsilon = 3$	0.38	0.77	-1.88	0.36	0.63	-1.15	0.33	0.33	0.33
$\epsilon = 4.6$	0.27	0.77	-2.59	0.26	0.63	-1.86	0.23	0.33	-0.37
$\theta = 1$	$\bar{\eta}_r = 1.3$			$\bar{\eta}_r = 1.6$			$\bar{\eta}_r = 3$		
	ξ_r	ξ_r^s	ξ_{rF}^N	ξ_r	ξ_r^s	ξ_{rF}^N	ξ_r	ξ_r^s	ξ_{rF}^N
$\epsilon = 1.3$	0.77	0.77	0.77	0.75	0.67	1.21	0.72	0.43	2.36
$\epsilon = 3$	0.37	0.59	-0.94	**0.36**	**0.52**	**-0.59**	0.33	0.33	0.33
$\epsilon = 4.6$	0.26	0.55	-1.41	0.25	0.48	-1.09	0.23	0.31	-0.23
$\theta = 5$	$\bar{\eta}_r = 1.3$			$\bar{\eta}_r = 1.6$			$\bar{\eta}_r = 3$		
	ξ_r	ξ_r^s	ξ_{rF}^N	ξ_r	ξ_r^s	ξ_{rF}^N	ξ_r	ξ_r^s	ξ_{rF}^N
$\epsilon = 1.3$	0.77	0.77	0.77	0.75	0.72	0.93	0.70	0.56	1.48
$\epsilon = 3$	0.36	0.42	-0.13	0.35	0.42	-0.03	0.33	0.33	0.33
$\epsilon = 4.6$	0.24	0.33	-0.38	0.24	0.33	-0.30	0.23	0.27	0.00

	ξ_r^l		
	$\psi = 0$	$\psi = 0.3$	$\psi = 1$
$\nu = 0$	1.00	0.97	0.94
$\nu = 1.5$	1.00	**0.96**	0.93
$\nu = 5$	0.99	0.96	0.93

Note: These tables report the simple cross-regional averages of the composite elasticities ξ_r, ξ_r^s, ξ_{ro}^N for o = Farming, and ξ_r^l under alternative parameterizations. ξ_r^l is computed under our baseline parameterization for η_r, θ, and ϵ. We use bold font to highlight our baseline calibration.

appears not to be a large force quantitatively.

Because the analytical results are for an economy with only nontradeables, the sensitivity analysis using the ξ_r, ξ_r^s, ξ_{ro}^N, and ξ_r^l does not cover the Armington elasticity χ. In the baseline we adopt a value of $\chi = 2$ following Boehm, Levchenko, and Pandalai-Nayar (2023). Appendix Figure A3 presents the results under a higher value of the $\chi = 7$, following Burstein et al. (2020). Panel A displays the regional native wages, while Panel B displays the native wages by occupation. Comparing these to the baseline results in Figures 4 and 6, it is clear that the real wage changes are not sensitive to the value of χ, in either the average magnitudes or the variation across states or occupations. The wage changes for authorized and unauthorized immigrants are equally similar to the baseline and we do not report them here. Panel C presents the results for the relative sectoral consumer prices. The price changes are somewhat attenuated relative to the baseline under χ =2: while Food prices rose by 1.2% relative to CPI in the baseline, under $\chi = 7$ they rose by 1%. The attenuation makes sense, as a higher Armington elasticity allows for easier substitution for foreign goods when the domestic Food prices increase.

5 Conclusion

This paper provides a quantification of the effects of a large decrease in the number of unauthorized workers in the US using a multi-region multi-occupation multi-sector model of the United States. The model is calibrated using a new approach to impute legal status within the ACS, which also allows us to document for the first time the occupational, regional and sectoral patterns in worker composition by immigration status. We show that a uniform 50% reduction in the unauthorized workforce (approximately 2.5 million workers) leads to modest nationwide wage increases for US-citizen workers in the short run, followed by wage declines of larger magnitude in the long run. These aggregate nationwide figures, however, mask highly heterogeneous impacts across regions and occupations.

Immigration policies have several dimensions. In addition to the stated deportation goal of 4 million workers — a figure that includes both unauthorized individuals and those with temporary legal status, such as beneficiaries of TPS, there are ongoing efforts to prevent further illegal border crossings. Our framework can be easily employed to evaluate the economic consequences of this broader package of policies, including closing the southern border and reclassifying some of the currently authorized workers as unauthorized and deporting (some of) them. At the same time, our analysis pertains primarily to wages and incomes, and does not speak to other important aspects of migration policies, such as their fiscal, political, and humanitarian consequences.

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ONLINE APPENDIX

(NOT FOR PUBLICATION)

A Data assembly

A.1 Worker data

A.1.1 Immigration status assignment

This section describes in detail the assignment of immigration status to respondents of the 2023 American Community Survey (ACS). Our algorithm follows closely Connor (2024), who developed the method and applied it to the 2022 ACS.

Traditionally, unauthorized workers were considered to be foreigners lacking residence permits and therefore at risk of being deported back to their countries of origin. Research on the characteristics of this population has been severely limited by lack of information on immigration status in large-scale surveys. Over the last decade, an increasing number of individuals have received administrative protections from deportation, such as DACA, TPS or asylum-seeker status, which also provide work authorization but lack a track toward legal permanent residence or citizenship.

To address the data shortcoming, demographers have developed a methodology to assign unauthorized status to individuals in the ACS and CPS. Among others, Warren and Warren (2013) and Passel and Cohn (2014) have led the development of the methodology over the last decade. However, until very recently, immigrant status assignment methods did not differentiate between fully unauthorized workers and those with temporary protection from deportation. Connor (2024) addresses this problem by extending the assignment method to identify various protected groups, separately from fully unauthorized individuals. His analysis relies on the 2022 ACS and publicly available auxiliary administrative data from various sources regarding recent border crossings and visa issuances. Besides partitioning the broad unauthorized status category, his analysis also adjusts the survey weights to better represent the immigrant population in 2023 by accounting for recent 2022 and 2023 arrivals that are unlikely to have been sampled due to their transient status.

In our paper, we implement the method in Connor (2024) on the 2023 ACS (Ruggles et al., 2015) and project it forward to make it representative of the 2024 immigrant population. Our algorithm follows the steps below:

1. Immigrant population. It is well-established that the foreign-born population and, particularly, those with unauthorized status, are typically undercounted in nationally representative surveys (Van Hook et al., 2015). To mitigate this problem, we rely on Khubba, Heim, and Hong (2022) and re-weight the 2023 ACS on the basis of known 2020 Census undercounting of certain groups, which enlarges the total immigrant population by about 1 million (to 47.1 million).

2. Naturalized, legal permanent residents (LPR) and (non-immigrant) visa holders. We use ACS information to identify naturalized citizens and likely LPR and visa holders. Specifically, we combine information on nationality, occupation, educational attainment, social welfare program use, household arrangements (e.g. marriage to a US citizen), years in the US, and other variables. Foreign spouses and dependents of visa holders are also considered visa holders. We checked that the resulting estimates for each visa category we consider (F-1, M-1, H-1B, H-2B, H-2A, J, L, O, P, R and TN) are in line with the issuance totals reported in government sources (DHS, Department of State, Department of Labor) or in Open Doors (`https://opendoorsdata.org`).

3. Deferred Action for Childhood Arrivals (DACA) and Temporary Protected Status (TPS). DACA was introduced in 2012 by President Obama in order to offer protection to unauthorized youth who entered the US as children. Temporary Protected Status is meant to last up to 18 months and offer temporary relief from deportation due to unsafe country of origin conditions. Similar to the assignments in the previous group, we use information on nationality, occupation, education, parents' and spouses' status, and year of arrival in the country to identify individuals who are likely to have DACA or TPS status. Specifically, we consider an individual as likely eligible for DACA if he/she satisfies the following conditions: (1) arrived in the US before 2008, (2) younger than 16 upon arrival, (3) age 42 years old or younger in 2023, (4) graduated from high school (or GED) or currently studying full time. The number of DACA-eligible individuals is larger than the actual number of recipients. To address the discrepancy, we randomly assign DACA recipient status according to the number of valid DACA recipients reported by USCIS as of 2023. We match sex-specific population group targets for Mexican and non-Mexican DACA recipients in top recipient states (California, Texas, and all other states combined). DACA spouses eligible for DACA and married to a DACA recipient are also assigned recipient status.

4. Unauthorized status. Likely unauthorized immigrants are obtained by subtracting (likely) naturalized immigrants, LPR, visa holders (step 2), and likely DACA or TPS recipients (step 3) from the foreign-born population (step 1). The number of likely unauthorized individuals (with or without temporary protection) we obtain is similar to the target values obtained from administrative sources. As a result, we do not need to randomly select individual cases in order to match the target unauthorized population in administrative sources.

5. Projection forward to the end of the 2024 fiscal year. We use publicly available government data on border crossings, asylum seekers and parole permits to account for 2023 and 2024 unauthorized inflows, asylum seekers, and individuals admitted through parol. We do so by adjusting upward the 2023 ACS survey weights of the likely unauthorized individuals (by nationality and age).

6. Protected status (besides DACA and TPS). Central to our analysis, we also identify the subset of (likely) unauthorized individuals with protected status (from deportation). We only assign protected status to individuals already considered unauthorized that were not deemed to be DACA or TPS recipients. We do this iteratively in the following order: Adjustment to Permanent Status (protecting individuals waiting to receive their green card or employment-based visa shortly), Special Immigrant Juvenile Status (protecting unauthorized youth from parental abuse or neglect), Adjustment to Nonimmigrant status (occasionally conferred to witnesses or victims of criminal activity), Asylum seekers, and Parole (offering protection to individuals due to humanitarian or security considerations).[18] According to our data, in 2024 the protected population makes up nearly half of the total unauthorized population. Among them, the 5 largest protected groups are asylum seekers, paroled individuals, recipients of TPS, and DACA recipients, and (non-immigrant) visa holders.

7. Regrouping into two groups. Currently, our theoretical framework splits the unauthorized population in two categories: those with temporary protection from deportation (grouped together with LPR and visa-holders) and those lacking any such protection. We label these groups *authorized* and *unauthorized*, respectively. Because our focus is on working-age individuals, the key distinction from an economic point of view is that one group can legally work while the other cannot. As illustrated by several studies on the effects of DACA, the authorized-unauthorized distinction shapes unauthorized workers' occupational choices, productivity, and wages (Pope, 2016; Amuedo-Dorantes and Antman, 2017; Hsin and Ortega, 2018; Borjas and Cassidy, 2019; Ortega and Hsin, 2022; Zaiour, 2023; Villanueva-Kiser and Wilson, 2024).

[18] We assign a single protected status to each individual, even if more than one were possible.

A.2 Construction of the trade and production shares

Throughout, let the regular font denote objects in the model, and the `typewriter` font denote pieces of data sourced from various databases. The shares required for the model solution are assembled from various sources, and harmonized across sources. There are 3 types of sectors: (i) those for which Commodity Flow Survey (CFS) data for internal US trade are available; (ii) tradeable sectors for which CFS data are not available; and (iii) non-tradeable sectors. There are 2 types of regions: (i) inside the US, and (ii) the rest of the world. This section describes how data are built for each type of sector and region. It may help to visualize the required pieces of information using the following graphic for sector s:

$$\begin{array}{ccccccc}
\text{Importer } r' \rightarrow & & & & & & \\
\text{Exporter } r \downarrow & & & & & & \\
 & \text{State 1} & \text{State 2} & \cdots & \text{State } \mathcal{R}\text{-1} & \text{ROW} & \\
\text{State 1} & P_{1s}Y_{11s} & P_{1s}Y_{12s} & \cdots & P_{1s}Y_{1,\mathcal{R}-1,s} & P_{1s}Y_{1,\mathcal{R}s} & \\
\text{State 2} & P_{2s}Y_{21s} & \ddots & & & \vdots & \\
\vdots & \vdots & & P^y_{rs}Y_{rr's} & & \vdots & \rightarrow \quad P^y_{rs}Y_{rs} \\
\text{State } \mathcal{R}\text{-1} & P_{\mathcal{R}-1s}Y_{\mathcal{R}-1,1s} & \cdots & & \ddots & P_{\mathcal{R}-1,s}Y_{\mathcal{R}-1,\mathcal{R}s} & \\
\text{ROW} & P_{\mathcal{R}s}Y_{\mathcal{R},1s} & \cdots & \cdots & \cdots & P_{\mathcal{R}s}Y_{\mathcal{R},\mathcal{R}s} & \\
 & & & \downarrow & & & \\
 & & & P_{r's}X_{r's} & & &
\end{array}$$

A.2.1 Production and Trade: CFS sectors

For these sectors, which are primarily manufacturing, we have the following data:

$\mathtt{Trade}^{\mathtt{CFS}}_{\mathtt{rr's}}$	total shipments from r to r' in sector s	CFS
$\mathtt{W_{rs}L_{rs}}^{\mathtt{ACS}}$	total wage bill in sector s, region r	ACS
$\mathtt{DomSales}^{\mathtt{IO}}_{\mathtt{s}}$	the total sales by US producers to US buyers	BEA IO
$\mathtt{Exports}^{\mathtt{IO}}_{\mathtt{s}}$	the total US exports of sector s	BEA IO
$\mathtt{Imports}^{\mathtt{IO}}_{\mathtt{s}}$	the total US imports in sector s	BEA IO
$\mathtt{Exports}^{\mathtt{CENSUS}}_{\mathtt{r},\mathcal{R},\mathtt{s}}$	exports from state r to the rest of the world in sector s	Census
$\mathtt{Imports}^{\mathtt{CENSUS}}_{\mathcal{R},\mathtt{r'},\mathtt{s}}$	imports to state r' to the rest of the world in sector s	Census
$\mathtt{Sales}^{\mathtt{ICIO}}_{\mathtt{USi}}$,$\mathtt{Sales}^{\mathtt{ICIO}}_{\mathcal{R}\mathtt{i}}$	sales (or exports) from country r to country r' in broad industry i	ICIO

We first apportion the aggregate US sales by domestic firms to domestic buyers according to region r's share in sector s's national wage bill from ACS:

$$P^y_{rs}Y_{rs} - P^y_{rs}Y_{r\mathcal{R}s} = \frac{\mathtt{W_{rs}L_{rs}}^{\mathtt{ACS}}}{\sum_{\mathtt{r'}} \mathtt{W_{r's}L_{r's}}^{\mathtt{ACS}}} \times \mathtt{DomSales}^{\mathtt{IO}}_{\mathtt{s}}$$

We then apportion region r's total sales to all US destinations according to CFS data. We compute domestic to domestic sales by apportioning $\mathtt{DomSales}^{\mathtt{IO}}_{\mathtt{s}}$ according to CFS shares ($r, r' \in US$):

$$P^y_{rs}Y_{rr's} = \frac{\mathtt{Trade}^{\mathtt{CFS}}_{\mathtt{rr's}}}{\sum_{\mathtt{q'}\in\mathtt{US}} \mathtt{Trade}^{\mathtt{CFS}}_{\mathtt{rq's}}} \times \left(P^y_{rs}Y_{rs} - P^y_{rs}Y_{r\mathcal{R}s}\right).$$

We compute US region to ROW sales (last column of the trade matrix) by apportioning $\texttt{Exports}_\texttt{s}^\texttt{IO}$ according to the wage bill shares from ACS ($r \in US, r' = \mathcal{R}$):

$$P^y_{rs} Y_{r\mathcal{R}s} \quad = \quad \frac{\texttt{W}_\texttt{rs}\texttt{L}_\texttt{rs}{}^\texttt{ACS}}{\sum_{\texttt{r}'} \texttt{W}_{\texttt{r}'\texttt{s}}\texttt{L}_{\texttt{r}'\texttt{s}}{}^\texttt{ACS}} \times \texttt{Exports}_\texttt{s}^\texttt{IO}.$$

We compute ROW to US sales (last row of the trade matrix) by apportioning $\texttt{Imports}_\texttt{s}^\texttt{IO}$ according to import shares in the census ($r = \mathcal{R}, r' \in US$):

$$P^y_{\mathcal{R}s} Y_{\mathcal{R},r's} \quad = \quad \frac{\texttt{Imports}^\texttt{CENSUS}_{\mathcal{R},\texttt{r}',\texttt{s}}}{\sum_{\texttt{q}\in\texttt{US}} \texttt{Imports}^\texttt{CENSUS}_{\mathcal{R},\texttt{q},\texttt{s}}} \times \texttt{Imports}_\texttt{s}^\texttt{IO}.$$

ROW to ROW sales ($r, r' = \mathcal{R}$) have to come from ICIO. We populate ROW to ROW sales in such a way that the ratio of total US sales to total ROW sales equals the value in ICIO. Because we only have industries i and not sectors s, we need an assumption on how ICIO industry i sales are apportioned to finer sectors s. We assume that the sales are apportioned to s within i in the same way in the US and ROW. In that case, the ROW to ROW sales are inferred as:

$$P^y_{\mathcal{R}s} Y_{\mathcal{R},\mathcal{R}s} \quad = \quad \frac{\texttt{Sales}^\texttt{ICIO}_{\mathcal{R},\texttt{US},\texttt{i}} + \texttt{Sales}^\texttt{ICIO}_{\mathcal{R},\mathcal{R},\texttt{i}}}{\texttt{Sales}^\texttt{ICIO}_{\texttt{US},\texttt{US},\texttt{i}} + \texttt{Sales}^\texttt{ICIO}_{\texttt{US},\mathcal{R},\texttt{i}}} \times \left[\texttt{DomSales}_\texttt{s}^\texttt{IO} + \texttt{Exports}_\texttt{s}^\texttt{IO}\right] - \texttt{Imports}_\texttt{s}^\texttt{IO}.$$

Note that the ratio in the beginning of the expression is simply the ratio of total sales by ROW (to every part of the world) to total sales by the US to every part of the world.

A.2.2 Production and Trade: Non-CFS Sectors

To calibrate these shares, we require the following data:

$\texttt{DomSales}_\texttt{s}^\texttt{IO}$	the total sales of sector s in total US – this is the *column* sum, minus exports	BEA IO
$\texttt{Exports}_\texttt{s}^\texttt{IO}$	the total US exports of sector s	BEA IO
$\texttt{Imports}_\texttt{s}^\texttt{IO}$	the total US imports in sector s	BEA IO
$\texttt{W}_\texttt{rs}\texttt{L}_\texttt{rs}{}^\texttt{ACS}$	total wage bill in sector s, region r	ACS
$\texttt{PCE}_\texttt{rs}^\texttt{BEA}$	state r personal consumption expenditure in sector s	BEA REA
$\texttt{Sales}_{\texttt{rr}'\texttt{i}}^\texttt{ICIO}$	sales (or exports) from country r to country r' in broad industry i	ICIO

The first step is to compute $P^y_{rs} Y_{rs}$ and $P_{r's} X_{r's}$. For the US states, we can compute them by apportioning national domestic revenues and expenditures appearing in the IO tables according to ACS wage bill shares:

$$P^y_{rs} Y_{rs} \quad = \quad \frac{\texttt{W}_\texttt{rs}\texttt{L}_\texttt{rs}}{\sum_{\texttt{r}'\in US} \texttt{W}_{\texttt{r}'\texttt{s}}\texttt{L}_{\texttt{r}'\texttt{s}}} \times \left[\texttt{DomSales}_\texttt{s}^\texttt{IO} + \texttt{Exports}_\texttt{s}^\texttt{IO}\right].$$

For non-tradeable sectors, that is all that is required, since all the cross-region trade values are zero:

$$\begin{aligned} P^y_{rrs} Y_{rrs} &= P^y_{rs} Y_{rs} \\ P^y_{rr's} Y_{rr's} &= 0 \, \forall r' \neq r. \end{aligned}$$

By the same token, local purchases equal local sales in nontradeable sectors: $P_{rs}X_{rs} = P^y_{rs}Y_{rs}$.[19] Non-tradeable sector output/purchases in ROW are obtained by simply rescaling the ROW sales such that the ratio of US to ROW sales matches what appears in ICIO:

$$P^y_{\mathcal{R}s}Y_{\mathcal{R},\mathcal{R}s} = P^y_{\mathcal{R}s}Y_{\mathcal{R}s} = P_{\mathcal{R}s}X_{\mathcal{R}s} = \frac{\mathtt{Sales}^{\mathtt{ICIO}}_{\mathcal{R},\mathtt{US},\mathtt{i}} + \mathtt{Sales}^{\mathtt{ICIO}}_{\mathcal{R},\mathcal{R},\mathtt{i}}}{\mathtt{Sales}^{\mathtt{ICIO}}_{\mathtt{US},\mathtt{US},\mathtt{i}} + \mathtt{Sales}^{\mathtt{ICIO}}_{\mathtt{US},\mathcal{R},\mathtt{i}}} \times \mathtt{DomSales}^{\mathtt{IO}}_{\mathtt{s}}.$$

For tradeable non-CFS sectors, we follow the procedure in Rodríguez-Clare, Ulate, and Vasquez (2025) and use adding-up constraints and how trade responds to gravity variables to infer bilateral trade values. The procedure requires, for each region, sales $P^y_{rs}Y_{rs}$ and purchases $P_{rs}X_{rs}$, as well as bilateral distance between each region. That paper should be consulted for further detail.[20] The sales are constructed as above. For purchases, we apportion aggregate US purchases to regions based on the region-sector personal consumption expenditure (PCE) from the BEA Regional Economic accounts:

$$P_{r's}X_{r's} = \frac{\mathtt{PCE}^{\mathtt{BEA}}_{\mathtt{r's}}}{\sum_{\mathtt{r}} \mathtt{PCE}^{\mathtt{BEA}}_{\mathtt{rs}}} \times \left[\mathtt{DomSales}^{\mathtt{IO}}_{\mathtt{s}} + \mathtt{Imports}^{\mathtt{IO}}_{\mathtt{s}}\right].$$

For ROW, we will construct internal trade first, in the same way as for CFS sectors:

$$P^y_{\mathcal{R}s}Y_{\mathcal{R},\mathcal{R}s} = \frac{\mathtt{Sales}^{\mathtt{ICIO}}_{\mathcal{R},\mathtt{US},\mathtt{i}} + \mathtt{Sales}^{\mathtt{ICIO}}_{\mathcal{R},\mathcal{R},\mathtt{i}}}{\mathtt{Sales}^{\mathtt{ICIO}}_{\mathtt{US},\mathtt{US},\mathtt{i}} + \mathtt{Sales}^{\mathtt{ICIO}}_{\mathtt{US},\mathcal{R},\mathtt{i}}} \times \left[\mathtt{DomSales}^{\mathtt{IO}}_{\mathtt{s}} + \mathtt{Exports}^{\mathtt{IO}}_{\mathtt{s}}\right] - \mathtt{Imports}^{\mathtt{IO}}_{\mathtt{s}}.$$

Then ROW sales $P^y_{\mathcal{R}s}Y_{\mathcal{R}s}$ and ROW purchases $P_{\mathcal{R}s}X_{\mathcal{R}s}$are obtained by adding BEA exports and imports, respectively:

$$\begin{aligned} P^y_{\mathcal{R}s}Y_{\mathcal{R}s} &= \sum_{r\in US} P^y_{\mathcal{R}s}Y_{\mathcal{R}rs} + P^y_{\mathcal{R}s}Y_{\mathcal{R},\mathcal{R}s} \\ &= \mathtt{Exports}^{\mathtt{IO}}_{\mathtt{s}} + P^y_{\mathcal{R}s}Y_{\mathcal{R},\mathcal{R}s}. \end{aligned}$$

$$\begin{aligned} P_{\mathcal{R}s}X_{\mathcal{R}s} &= \sum_{r'\in US} P^y_{r's}Y_{r'\mathcal{R}s} + P^y_{\mathcal{R}s}Y_{\mathcal{R},\mathcal{R}s} \\ &= \mathtt{Imports}^{\mathtt{IO}}_{\mathtt{s}} + P^y_{\mathcal{R}s}Y_{\mathcal{R},\mathcal{R}s}. \end{aligned}$$

A.2.3 Harmonization of wage bill, output, expenditure, and trade shares

The ACS is the source of the region-level wage bill share:

$$s_{rs} = \frac{\mathtt{W}_{\mathtt{rs}}\mathtt{L}_{\mathtt{rs}}}{\sum_{\mathtt{s'}}\mathtt{W}_{\mathtt{rs'}}\mathtt{L}_{\mathtt{rs'}}}.$$

It has the following relation to the share of sectors in the aggregate gross output:

$$s^y_{rs} \equiv \frac{P^y_{rs}Y_{rs}}{\sum_{s'} P^y_{rs'}Y_{rs'}} = \frac{s_{rs}/\left[\kappa_s\left[1-\alpha_s\right]\right]}{\sum_{s'} s_{rs'}/\left[\kappa_{s'}\left[1-\alpha_{s'}\right]\right]}. \quad \text{(A.1)}$$

[19]In practice, for sectors we classify as non-tradeable, $\mathtt{Exports}^{\mathtt{IO}}_{\mathtt{s}}$ are negligible.

[20]We are grateful to the authors for sharing the code and helpful discussions.

The nationwide s_s^y is sourced from the BEA IO tables. We use this relation to compute the vector of α_s's. In a small number of cases in which this results in a share of labor in value added greater than 1, we winsorize the resulting α_s to match the largest observed share of labor in value added that is less than 1. In practice, setting α_s this way produces values that are highly correlated with simply reading α_s's from the IO table, but it improves consistency between production data from the IO tables and the labor data from ACS. We obtain $1-\kappa_s$ as the share of intermediate input expenditure in gross output in the BEA IO tables.

With these values of α_s, we construct the region-specific revenue shares s_{rs}^y that are consistent with the ACS data on wage bill shares by region and sector using equation (A.1). The trade data now must be made consistent with the output shares above. Denote by a big tilde the original raw data as it comes from CFS. We adopt the following procedure:

Step 1: Compute total sales by each r as a sum of each row implied by the trade data:

$$\widetilde{P_{rs}^y Y_{rs}} = \sum_{r'} \widetilde{P_{rs}^y Y_{rr's}}.$$

Construct total sales by the region:

$$\sum_s \widetilde{P_{rs}^y Y_{rs}} = \sum_s \sum_{r'} \widetilde{P_{rs}^y Y_{rr's}}.$$

Step 2: Construct the export shares:

$$\varpi_{rr's}^x = \frac{\widetilde{P_{rs}^y Y_{rr's}}}{\widetilde{P_{rs}^y Y_{rs}}}$$

Step 3: Construct the new total sectoral sales by multiplying the total aggregate sales by the s_{rs}^y consistent with ACS (A.1):

$$P_{rs}^y Y_{rs} = s_{rs}^y \times \sum_s \widetilde{P_{rs}^y Y_{rs}}.$$

Step 4: Construct the final absolute bilateral sales by multiplying back:

$$P_{rs}^y Y_{rr's} = \varpi_{rr's}^x \times P_{rs}^y Y_{rs}.$$

From here proceed to construct the expenditures. The total expenditure is the total purchases in each column:

$$P_{r's} X_{r's} = \sum_r P_{rs}^y Y_{rr's},$$

and the shares:

$$\varpi_{rr's} = \frac{P_{rs}^y Y_{rr's}}{P_{r's} X_{r's}}.$$

Once we have the final versions of $P_{rs}X_{rs}$ and $P_{rs}^y Y_{rs}$ for each state and sector, we can also compute the required wedge share:

$$s^G_{rs} \quad = \quad 1 - \frac{\sum_{s'} \left[\gamma_s \kappa_{s'} + [1-\kappa_{s'}]\,\gamma_{ss'}\right] P^y_{rs'} Y_{rs'}}{P_{rs} X_{rs}}.$$

Given s^y_{rs} in (A.1), s^L_{rs}, s^K_{rs}, and $s^M_{rss'}$ can be constructed from (C.27), (C.28), and (C.29). Finally, λ^i_r are already implied by various other shares:

$$\lambda^i_r \quad = \quad \sum_o \lambda^i_{ro} \sum_s \phi_{rso} s_{rs}.$$

A.2.4 ROW Construction

In ROW, we do not have any of the labor-related shares from ACS. Trade data imply total sales, and therefore $s^y_{\mathcal{R}s}$:

$$s^y_{\mathcal{R}s} \quad = \quad \frac{P^y_{\mathcal{R}s} Y_{\mathcal{R}s}}{\sum_{s'} P^y_{\mathcal{R}s'} Y_{\mathcal{R}s'}}.$$

We use the one-to-one relationship between output shares and wage bill shares to infer the wage bill shares in the rest of the world:

$$s_{\mathcal{R}s} \quad = \quad \frac{[1-\alpha_s]\,\kappa_s s^y_{\mathcal{R}s}}{\sum_{s'} [1-\alpha_{s'}]\,\kappa_{s'} s^y_{\mathcal{R}s'}}.$$

Using US average occupational shares:

$$\phi_{\mathcal{R}so} \quad = \quad \frac{\sum_{r \neq \mathcal{R}} W_{ro} L_{rso}}{\sum_{r \neq \mathcal{R}} W_{rs} L_{rs}},$$

we construct the $\pi_{\mathcal{R}o}$ to be internally consistent for ROW:

$$\pi_{\mathcal{R}o} \quad = \quad \sum_s \phi_{\mathcal{R}so} s_{\mathcal{R}s}.$$

Also, rest of the world residents do not choose to locate in the US, and do not choose whether to supply labor. So we set $\pi_{\mathcal{R}} = 1$ and $\pi_{M,\mathcal{R}} = 1$.

A.3 Occupations and sectors

We aim to strike a balance between occupational granularity and the relatively small size of the unauthorized population when we break workers into states, sectors, and occupations. Keeping this in mind, our occupational categories are based on the 2018 Census occupational classification. Starting from 12 large occupational categories, we selected those with a minimum threshold number of unauthorized foreigners (2000 observations) and subdivided them into 3-digit occupations. The 3-digit occupations with fewer than a second threshold (200 observations) were grouped into a "Rest combined" subcategory.

Table A1: Occupations

Description	Code	Natives	Fgn workers	Fgn Auth.	Fgn Non-auth.	Share Fgn
All occupations		138.87	15.55	10.60	4.95	0.10
Farming, fishing, forestry occupations	800	0.529	1.063	0.322	0.741	0.67
Construction and Extraction: Brickmasons, carpenters, tile installers, laborers	962	2.421	1.080	0.566	0.514	0.31
Construction and Extraction: Roofers, steel workers, solar installers	965	0.307	0.128	0.059	0.069	0.29
Construction and Extraction: Painters, insulation workers, plumbers, plasterers	964	0.857	0.314	0.155	0.159	0.27
Production: Packagers, painters	1188	0.322	0.115	0.067	0.048	0.26
Sv. Personal: Housekeeping, Janitors, Landscaping	642	3.402	1.142	0.727	0.416	0.25
Production: Bakers, Meat processing, food processing	1178	0.561	0.140	0.083	0.058	0.20
Sv. Personal: Cooks, Bartenders, Food prep	640	4.539	0.903	0.559	0.344	0.17
Production: Helpers, miscellaneous operators	1189	1.353	0.265	0.159	0.105	0.16
Production: Cleaners equipment, movers, freight, packers and stockers	1196	5.253	0.842	0.521	0.320	0.14
Sv. Personal: Barbers, Manicurists	645	0.898	0.140	0.097	0.043	0.13
Sv. Personal: Waiters, Dishwashers	641	2.732	0.406	0.259	0.147	0.13
Construction and Extraction: Drywall installers, electricians, equipment operators	963	1.283	0.189	0.096	0.094	0.13
Production: Metal workers	1181	0.576	0.080	0.041	0.038	0.12
Computers and STEM professionals	300	11.300	1.541	1.340	0.200	0.12
Construction and Extraction: Rest combined	999	0.494	0.066	0.036	0.030	0.12
Production: Rest combined	1199	2.003	0.257	0.157	0.100	0.11
Production: Assemblers	1177	1.770	0.211	0.122	0.089	0.11
Production: Appliance technicians	1187	0.927	0.103	0.069	0.034	0.10
Sales Admin: Production, planning, and expediting clerks	756	0.811	0.089	0.055	0.034	0.10
Sv. Personal: Childcare, recreation workers, personal care	646	1.171	0.128	0.089	0.038	0.10
Transportation	1200	5.629	0.595	0.401	0.194	0.10
Equipment	1000	4.403	0.418	0.257	0.161	0.09
Sales Admin: Retail sales, cashiers	747	8.602	0.661	0.441	0.220	0.07
Health	500	14.000	0.991	0.863	0.128	0.07
Managers	100	16.500	1.091	0.877	0.214	0.06
Sales Admin: Receptionists and information clerks	754	1.326	0.083	0.059	0.025	0.06
Sales Admin: Rest combined	799	4.898	0.306	0.227	0.079	0.06
Sales Admin: Customer service representatives, municipal and court clerks	752	3.162	0.191	0.129	0.062	0.06
Social and Media	400	13.500	0.795	0.729	0.066	0.06
Sales Admin: Data entry, typists, insurance claims clerks, office clerks general	758	1.707	0.101	0.071	0.030	0.06
Business, Finance, Legal	200	10.700	0.610	0.571	0.039	0.05
Sales Admin: Sales representatives, sales agents	748	2.569	0.130	0.095	0.035	0.05
Sales Admin: Billing collectors and clerks, tellers, bookkeeping	751	2.111	0.107	0.080	0.027	0.05
Sales Admin: Executive secretaries, medical secretaries, administrative assist.	757	2.179	0.101	0.071	0.031	0.04
SV. Personal: Rest combined	699	4.074	0.171	0.152	0.019	0.04

Note: This table lists the occupations used in the analysis

Table A2: Sectors

Description	NAICS 3 Digit	Description	NAICS 3 Digit
Farms	111, 112	Other transportation	485, 486, 487, 488, 492, 493
Forestry and Fishing	113, 114, 115	Fed govt. enterprises	491
Oil & gas, mining	211, 212, 213, 324	Media & sound recording	512
Utilities	221	Publishing & internet	513, 516, 517, 518, 519
Construction	23	Finance & investments	521, 522, 523, 525
Food & tobacco mfg.	311, 312	Insurance	524
Textiles & apparel	313, 314, 315, 316	Real estate	531
Wood & paper products	321, 322	Rental & leasing	532, 533
Printing & support	323	Legal & tech services	55, 541
Chemical products	325	Admin support services	561
Plastics & rubber	326	Waste management	562
Nonmetal mineral products	327	Education	611
Metal products	331, 332	Ambulatory care	621
Machinery	333	Hospitals	622
Computers & electronics	334	Nursing care	623
Electrical equipment	335	Social assistance	624
Motor & transportation equipment	336	Arts & museums	711, 712
Furniture	337	Amusements & gambling	713
Misc manufacturing	339	Accommodation	721
Wholesale trade	423, 424, 425	Food & drink services	722
Retail trade	441, 445, 455, 444, 456, 457, 458, 449, 459	Other services (non-govt)	811, 812, 813, 814
Air/Rail/Truck transportation.	481, 482, 483, 484	Public admin & military	92

Note: This table lists the sectors used in the analysis.

B Theory

B.1 Equilibrium characterization

This section characterizes the equilibrium of the model presented in Section 3.

B.1.1 US household problem

We being by solving the problem of US households. The expected price index in region r is

$$\ln P_{rt} \equiv \int a_t(h) \ln p_{rt}(h) dG_{\gamma,a}(h) = \int a_t(h) \left[\sum_s \gamma_{st}(h) \ln P_{rst} \right] dG_{\gamma,a}(h) = \sum_s \gamma_s \ln P_{rst}.$$

or

$$P_{rt} = \prod_s P_{rst}^{\gamma_s}. \tag{B.1}$$

To solve for Υ_r^i, note that the average value of the shifter $\zeta_j(\omega, h)$ is $\mathbb{E}\left[\zeta_j(\omega,h) | \omega \text{ choose } j\right] = -\psi \ln \pi_{j,r}^i$. Substituting in the definition of Υ_r^i we obtain

$$\begin{aligned} \ln \Upsilon_{rt}^i &= \sum_j \pi_{j,r}^i \left[V_{j,rt}^i + \mathbb{E}\left[\zeta_j(\omega,h) | \omega \text{ choose } j\right] \right] \\ &= \psi \ln \left[\exp\left\{ \frac{V_{M,rt}^k}{\psi} \right\} + \exp\left\{ \frac{V_{H,rt}^i}{\psi} \right\} \right]. \end{aligned}$$

We can then write

$$\left[\Upsilon_{rt}^i\right]^\psi = \left[\frac{W_{rt}^i}{P_{rt}}\right]^\psi + \left[c_{H,rt}^i\right]^\psi. \tag{B.2}$$

We now solve for the occupation decisions, which satisfy

$$o_{rt}^i(\omega,h) = \arg\max_o \; a_t(h) W_{rot}^i Z_{rot}^i \varepsilon_{ot}(\omega,h).$$

The fraction of members allocated to occupation o is given by (4). A household with $a(h) = 1$ has labor earnings of $\pi_{M,rt}^i W_{rt}^i$, where

$$W_{rt}^i \equiv \mathbb{E}\left[\max_o W_{rot}^i Z_{rot}^i \epsilon_o(\omega,h)\right] = \Gamma\left(\frac{\theta}{1+\theta}\right) \left[\sum_o \left[Z_{rot}^i W_{rot}^i\right]^{1+\theta} \right]^{\frac{1}{1+\theta}}, \tag{B.3}$$

and Γ is the Gamma function.

Aggregation: To obtain the aggregate labor supplies and consumption choices, note that the total efficiency units of of type i labor supplied to occupation o in region r is

$$\begin{aligned} L^i_{rot} &= H^i_t \pi^i_{rt} \pi^i_{M,rt} Z^i_{ro,t} \int a_t(h)\, \mathbb{E}\left[\varepsilon_o(\omega,h)\,|\omega \text{ choose o}\right] dG_{a,\varepsilon}(h) \\ &= \Gamma H^i_t \pi^i_{rt} \pi^i_{M,rt} Z^i_{rot} \left[\pi^i_{rot}\right]^{\frac{\theta}{1+\theta}}. \end{aligned}$$

Total consumption by type k households of sectoral good s is

$$P_{rst} C^i_{rst} = H^i_t \pi^i_{rt} \int P_{rst} c^i_{rst}(h) dh = \gamma_s H^i_t \pi^i_{rt} \pi^i_{M,rt} W^i_{rt}.$$

B.1.2 Regional capitalists

The treatment of regional capitalists follows Kleinman, Liu, and Redding (2023). We assume log period utility. Let $v_r(K_{rt};t)$ denote the value function of the capitalist in region r at time t, which can be written recursively as

$$\begin{aligned} v_r(K_{rt};t) &= max_{\left\{C^K_{rt}, K_{rt+1}\right\}} \ln C^K_{rt} + \beta \mathbb{E}_t\left[v_r(K_{rt+1};t+1)\right] \\ & s.t. \\ C^K_{rt} + K_{rt+1} &\leq Q_{rt} K_{rt}, \end{aligned}$$

with $Q_{rt} \equiv \left[\frac{R_{rt}}{P_{rt}} + 1 - \delta\right]$. The first-order conditions are

$$\begin{aligned} \frac{1}{C^K_{rt}} &= \varepsilon_t \\ \beta \frac{dv_r(K_{rt+1};t+1)}{dK_{rt}} &= \varepsilon_t, \end{aligned}$$

where ε_t is the Lagrange multiplier on the time-t budget constraint, and the envelope condition is

$$\frac{dv_r(K_{rt};t)}{dK_{rt}} = \frac{Q_{rt}}{C^K_{rt}}.$$

Combining these equations yields the Euler equation

$$\beta \frac{Q_{rt+1}}{C^K_{rt+1}} = \frac{1}{C^K_{rt}}.$$

We guess and verify that there exists some constant $\mathtt{m_t}$ such that optimal policy is $C^K_{rt} = \mathtt{m_t} Q_{rt} K_{rt}$. Then the budget constraint implies $K_{rt+1} = [1 - \mathtt{m_t}]\, Q_{rt} K_{rt}$. Plugging the guess into the Euler equation yields

$$\mathtt{m}_t = 1 - \beta.$$

Then capital stock evolves according to

$$K_{r,t+1} = \beta \left[\frac{R_{r,t}}{P_{r,t}} + 1 - \delta \right] K_{r,t}. \tag{B.4}$$

The demand for sectoral good comprises the use of the good for consumption and for investment:

$$X^K_{rst} = \frac{\gamma_s}{P_{rs}} R_{r,t} K_{r,t}. \tag{B.5}$$

B.1.3 Factor demands

We now derive the factor demands implied by the production functions. The price P^y_{rst} of region r's variety in sector s is:

$$P^y_{rst} = \left[R^{\alpha_s}_{rt} W^{1-\alpha_s}_{rst} \right]^{\kappa_s} \left[\Pi_{s'} P^{\gamma_{s's}}_{rs't} \right]^{1-\kappa_s}. \tag{B.6}$$

Sector s's labor, capital, and intermediate input demands satisfy

$$W_{rst} L_{rst} = \kappa_s \left[1 - \alpha_s \right] P^y_{rst} Y_{rst}, \tag{B.7}$$

$$R_{rt} K_{rst} = \kappa_s \alpha_s P^y_{rst} Y_{rst}, \tag{B.8}$$

and

$$P_{rst'} M_{rs'st} = \left[1 - \kappa_s \right] \gamma_{s's} P^y_{rst} Y_{rst}. \tag{B.9}$$

The demand for occupation o in each in each sector-region is

$$L_{rsot} = \bar{\phi}_{rso} \left[\frac{W_{rot}}{W_{rst}} \right]^{-\eta} L_{rst}, \tag{B.10}$$

where the ideal price for sector s labor bundle in region r is:

$$W_{rst} = \left[\sum_o \bar{\phi}_{rso} W^{1-\eta}_{rot} \right]^{\frac{1}{1-\eta}}. \tag{B.11}$$

The demands by occupation o in region r for natives and foreign immigrants are given by

$$L^N_{rot} = \bar{\lambda}_{ro} \left[\frac{W^N_{rot}}{W_{rot}} \right]^{-\epsilon} L_{rot}, \tag{B.12}$$

and

$$L^F_{rot} = \left[1 - \bar{\lambda}_{ro} \right] \left[\frac{W^F_{rot}}{W_{rot}} \right]^{-\epsilon} L_{rot}. \tag{B.13}$$

Here W^N_{rot} and W^F_{rot} are the prices of the native and foreign labor bundles and the occupation o ideal wage index in region r is:

$$W_{rot} = \left[\bar{\lambda}^N_{ro}\left[W^N_{rot}\right]^{1-\epsilon} + \left[1-\bar{\lambda}^N_{ro}\right]\left[W^F_{rot}\right]^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}. \tag{B.14}$$

Finally, the demands for authorized and unauthorized workers in occupation o and region r are

$$L^A_{rot} = \bar{\mu}_{ro}\left[\frac{W^A_{rot}}{W^F_{rot}}\right]^{-\sigma} L^F_{rot}, \tag{B.15}$$

and

$$L^U_{rot} = \left[1-\bar{\mu}_{ro}\right]\left[\frac{W^U_{rot}}{W^F_{rot}}\right]^{-\sigma} L^F_{rot}. \tag{B.16}$$

Here

$$W^F_{rot} = \left[\bar{\lambda}^A_{ro}\left[W^A_{rot}\right]^{1-\sigma} + \bar{\lambda}^U_{ro}\left[W^U_{rot}\right]^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{B.17}$$

is the ideal wage index of foreign-born labor in occupation o and region r.

Goods demands The demand by region r for region r' variety in sector s is

$$Y_{r'rst} = \bar{\varpi}_{r'rs}\left[\frac{P^y_{r'st}}{P_{rst}}\right]^{-\chi} X_{rst}, \tag{B.18}$$

whereP_{rst} is the price of sector s bundle in region r:

$$P_{rst} = \left[\sum_{r'}\bar{\varpi}_{r'rs}\left[P^y_{r'st}\right]^{1-\chi}\right]^{\frac{1}{1-\chi}}. \tag{B.19}$$

Equilibrium: An equilibrium is a set of prices and quantities $\{P_{rt}\}_{\forall r,t}$, $\left\{\Upsilon^i_{rt}, \pi^i_{M,rt}, W^i_{rt}, \pi^i_{rt}\right\}_{\forall r,i,t}$, $\{C^i_{rst}\}_{\forall rs,i,t}$, $\{W_{rot}, L_{rot}\}_{\forall ro,t}$, $\{L^N_{rot}, L^A_{rot}, L^U_{rot}\}_{\forall ro,t}$, $\{W^i_{rot}, \pi^i_{rot}\}_{\forall ro,t}$, $\{L^F_{rot}, W^F_{rot}\}_{\forall ro,t}$, $\{Y_{rst}, L_{rst}, K_{rst}, X^K_{rst}, \}_{\forall rs,t}$, $\{P_{rst}, P^y_{rst}, W_{rst}\}_{\forall rs,t}$, $\{X_{rst}\}_{\forall rs,t}$, $\{M_{rss't}\}_{\forall rss',t}$, $\{Y_{r'rst}\}_{\forall r'rs,t}$, $\{L_{rsot}\}_{\forall rso,t}$ and $\{R_{rt}, I_{rt}, C^K_{rt}\}_{\forall r,t}$ such that (i) consumers maximize utility; (ii) producers minimize costs; and (iii) all markets clear. The equilibrium allocation satisfies equations (5)-(11) and (B.1)-(B.19).

B.2 Proofs

B.2.1 Proof of Proposition 1

Relative wages We first characterize all the changes in relative wages as a function of the relative labor supplies of natives vs immigrants. We omit time subscripts in this section to simplify the exposition. We can write the change in labor in occupation o as:

$$l_{ro} = \sum_s \frac{L_{rso}}{L_{ro}} l_{rso} = \sum_s \frac{\phi_{rso} s_{rs}}{\sum_{s'} \phi_{rs'o} s_{rs'}} l_{rso}.$$

Which in combination with the log linear version of (B.10) implies

$$l_{ro} = -\eta w_{ro} + \sum_s \frac{\phi_{rso} s_{rs}}{\sum_{s'} \phi_{rs'o} s_{rs'}} \left[\eta w_{rs} + l_{rs}\right]. \tag{B.20}$$

Log differentiating (B.7), and under the assumptions that $\gamma_{ss'} = \gamma_s$ and $s^G_{rs} = 0$; we can write

$$w_{rs} + l_{rs} = r_r + k_{rs} = p^y_{rs} + y_{rs} = p_{rs} + x_{rs} = p_r + x_r, \tag{B.21}$$

with $P_r X_r \equiv \sum_s P_{rs} X_{rs}$. Here the first two equalities follows from the Cobb-Douglas assumption in the production function, the second follows from assuming no trade, and the last one follows from the Cobb-Douglas assumption in the production of the absorption aggregates.

We define the average wage in region r as:

$$w_r \equiv \sum_i \lambda^i_r w^i_r = \sum_s s_{rs} w_{rs} = \sum_o s_{ro} w_{ro}, \tag{B.22}$$

where $\lambda^i_r \equiv \frac{W^i_r L^i_r}{\sum_i W^i_r L^i_r}$, $s_{rs} \equiv \frac{W_{rs} L_{rs}}{\sum_s W_{rs} L_{rs}}$ and $s_{ro} \equiv \frac{W_{ro} L_{ro}}{\sum_o W_{ro} L_{ro}}$. We also define the regional labor supply as

$$l_r \equiv \sum \lambda^i_r l^i_r = \sum_s s_{rs} l_{rs} = \sum_o s_{ro} l_{ro}. \tag{B.23}$$

In combination with (B.20) this can be re-arranged as

$$l_{ro} = -\eta \left[w_{ro} - w_r\right] + \left[\eta - 1\right] \sum_s \frac{\phi_{rso} s_{rs}}{\sum_{s'} \phi_{rs'o} s_{rs'}} \left[w_{rs} - w_r\right] + \left[p_r - w_r\right] + x_r.$$

With two occupations, we can rearrange this equation to write

$$\frac{l_{r2} - l_{r1}}{w_{r1} - w_{r2}} = \eta \left[1 - \varsigma_r\right] + \varsigma_r \equiv \bar{\eta}_r, \tag{B.24}$$

with weighting factor is given by $\varsigma_r \equiv \sum_s \frac{\left[\phi_{rso_1} - s_{ro_1}\right]^2 s_{rs}}{s_{ro_1}\left[1 - s_{ro_1}\right]}$. Log-differentiating equation (6) we obtain:

$$l^i_{ro} = l^i_r + \theta \left[w^i_{ro} - w^i_r\right],$$

where we defined

$$l^i_r \equiv h^i + \left[\nu \pi^i_{M,r} + \left[1 - \pi^i_{M,r}\right] \psi\right] \left[w^i_r - p_r\right] - \nu \left[w^i - p^i\right], \tag{B.25}$$

$w^i \equiv \sum_{r'=1}^{\mathcal{R}-1} \pi_r^i \pi_{M,r}^i w_r^i$ and $p^i \equiv \sum_{r'=1}^{\mathcal{R}-1} \pi_r^i \pi_{M,r}^i p_r$. Pre-multiplying by $\lambda_{ro}^i \equiv \frac{W_{ro}^i L_{ro}^i}{W_{ro} L_{ro}}$ and summing across $i's$ we obtain:

$$l_{ro} = \sum_i \lambda_{ro}^i l_r^i + \theta \left[w_{ro} - \bar{w}_{ro} \right], \tag{B.26}$$

where $\bar{w}_{ro} \equiv \sum_i \lambda_{ro}^i w_r^i$. Equation (B.22) can be written as:

$$w_r^N - w_r = \left[1 - \lambda_r^N \right] \left[w_r^N - w_r^F \right],$$

which implies

$$\bar{w}_{ro} - w_r = \frac{\lambda_{ro}^N - \lambda_r^N}{1 - \lambda_r^N} \left[w_r^N - w_r \right]. \tag{B.27}$$

Plugging (B.23), (B.26) and (B.27) into (B.24) yields

$$w_{ro} - w_r = \frac{\lambda_{ro}^N - \lambda_r^N}{\theta + \bar{\eta}_r} \left[\left[l_r^U - l_r^N \right] + \frac{\theta}{1 - \lambda_r^N} \left[w_r^N - w_r \right] \right]. \tag{B.28}$$

Log-differentiating equation (B.12) and (B.13) yields:

$$l_{ro}^N - l_{ro}^F = -\epsilon \left[w_{ro}^N - w_{ro}^U \right].$$

In combination with (B.26) yields

$$\left[\theta + \epsilon \right] \left[w_{ro}^N - w_{ro}^U \right] = l_r^U - l_r^N + \theta \left[w_r^N - w_r^U \right].$$

Using $w_{ro}^N - w_{ro} = \left[1 - \lambda_{ro}^N \right] \left[w_{ro}^N - w_{ro}^U \right]$ we obtain:

$$\left[\theta + \epsilon \right] \left[w_{ro}^N - w_{ro} \right] = \left[1 - \lambda_{ro}^N \right] \left[l_r^U - l_r^N \right] + \left[1 - \lambda_{ro}^N \right] \theta \left[w_r^N - w_r^U \right].$$

Pre-multiplying by π_{ro}^N and adding across occupations yields

$$w_r^N - \sum_o \pi_{ro}^N w_{ro} = \frac{\omega_r}{\theta + \epsilon} \left[1 - \lambda_r^N \right] \left[\left[l_r^U - l_r^N \right] + \theta \left[w_r^N - w_r^U \right] \right],$$

where $\omega_r \equiv \frac{1 - \sum_o \pi_{ro}^N \lambda_{ro}^N}{1 - \lambda_r^N}$. Pre-multiplying (B.28) by π_{ro}^N and adding across occupations yields

$$\sum_o \pi_{ro}^N w_{ro} - w_r = \frac{1 - \omega_r}{\theta + \bar{\eta}_r} \left[\left[1 - \lambda_r^N \right] \left[l_r^U - l_r^N \right] + \theta \left[w_r^N - w_r \right] \right].$$

Equating these formulas yields

$$w_r^N - w_r = \xi_r \lambda_r^U \left[l_r^U - l_r^N \right]. \tag{B.29}$$

with

$$\xi_r \equiv \frac{\theta + v_r}{\theta \mu_r + \epsilon \bar{\eta}_r} \geq 0.$$

where $v_r \equiv \omega_r \epsilon + [1 - \omega_r] \bar{\eta}_r$ and $\mu_r \equiv [1 - \omega_r] \omega_r + \epsilon \bar{\eta}_r$. The derivation of $w_r^U - w_r$ is very similar.

Then, substituting in (B.28) and adding across occupations within sector we get

$$w_{ro} - w_r = \xi_r^s \left[\lambda_{ro}^N - \lambda_r^N \right] \left[l_r^U - l_r^N \right], \tag{B.30}$$

and

$$w_{rs} - w_r = \xi_r^s \left[\lambda_{rs}^N - \lambda_r^N \right] \left[l_r^U - l_r^N \right], \tag{B.31}$$

with

$$\xi_r^s = \frac{\theta + \epsilon}{\theta \mu_r + \epsilon \bar{\eta}_r}.$$

Finally, we compute the remaining occupation level real wages, subtracting (B.29) from (B.30) we obtain,

$$w_{ro}^N - w_{ro} = \frac{\theta + \bar{\eta}_r}{\theta \mu_r + \epsilon \bar{\eta}_r} \left[1 - \lambda_{ro}^N \right] \left[l_r^U - l_r^N \right].$$

Similarly,

$$w_{ro}^U - w_{ro} = \frac{-\left[\bar{\eta} + \theta \right] \lambda_{ro}^N}{\theta \mu_r + \epsilon \bar{\eta}_r} \left[l_r^U - l_r^N \right].$$

We can then obtain

$$w_{ro}^N - w_r = \frac{\theta + v_{ro}^N}{\theta \mu_r + \epsilon \bar{\eta}_r} \lambda_r^U \left[l_r^U - l_r^N \right].$$

and

$$w_{ro}^U - w_r = -\frac{\theta + v_{ro}^U}{\theta \mu_r + \epsilon \bar{\eta}_r} \lambda_r^N \left[l_r^U - l_r^N \right].$$

with $v_o^i = \left[1 - \omega_{ro}^i \right] \epsilon + \omega_{ro}^i \bar{\eta}_r$ and $\omega_{ro}^i \equiv \frac{1 - \lambda_{ro}^i}{1 - \lambda_r^i}$.

Relative prices We now compute the changes in relative sectorial prices. Let

$$p_r^y \equiv \sum_s s_{rs}^y p_{rs}^y, \tag{B.32}$$

denote the change in the producer price index in region r, where $s^y_{rs} \equiv \frac{P^y_{rs} Y_{rs}}{\sum_s P^y_{rs} Y_{rs}}$ is the share of sector s in regional output. Log differentiating equation (B.6) yields:

$$p^y_{rs} = \kappa_s \alpha_s r_r + \kappa_s [1 - \alpha_s] w_{rs} + [1 - \kappa_s] \sum_{s'} \gamma_{s'} p_{rs'}.$$

From equation (B.32) we obtain

$$p^y_r = \sum_s s^y_{rs} \kappa_s \alpha_s r_r + \sum_s s^y_{rs} \kappa_s [1 - \alpha_s] w_{rs} + \sum_s s^y_{rs} [1 - \kappa_s] \sum_{s'} \gamma_{s'} p_{rs'}.$$

Assuming there is not trade, we have $p^y_{rs} = p_{rs}$, $\gamma_{s'} = s^y_{rs}$, and $p^y_r = p_r$. Then

$$p^y_{rs} - p_r = \kappa_s \alpha_s [r_r - p_r] + \kappa_s [1 - \alpha_s] [w_{rs} - p_r],$$

and

$$p^y_r - p_r = \kappa_r \alpha_r [r_r - p_r] + \sum_s s^y_{rs} \kappa_s [1 - \alpha_s] [w_{rs} - p_r].$$

Here $\alpha_r \equiv \frac{\sum_s R_r K_{rs}}{\sum_s W_{rs} L_{rs} K_{rs} + \sum_s R_r K_{rs}}$, and $\kappa_r \equiv \frac{\sum_s W_{rs} L_{rs} K_{rs} + \sum_s R_r K_{rs}}{\sum_s P^y_{rs} Y_{rs}}$. Note that

$$\sum_s s^y_{rs} \kappa_s [1 - \alpha_s] [w_{rs} - p_r] = \kappa_r [1 - \alpha_r] [w_r - p_r],$$

With no trade, we have $p^y_r = p_r$, so

$$[r_r - p_r] = -\frac{1 - \alpha_r}{\alpha_r} [w_r - p_r]. \tag{B.33}$$

Substituting back we obtain

$$p^y_{rs} - p_r = \kappa_s \left[[1 - \alpha_s] [w_{rs} - w_r] + \frac{\alpha_r - \alpha_s}{\alpha_r} [w_r - p_r] \right],$$

which in combination with equation (B.31) gives (15).

Real wages We now solve for the evolution of real wages $w_{rt} - p_{rt}$. Note that from the FOC's we obtain

$$\alpha_s W_{rs} L_{rs} = [1 - \alpha_s] R_r K_{rs}.$$

Adding across sectors and log differentiating yields

$$r_r + k_r = \sum_{s'} \frac{\frac{\alpha_s}{1-\alpha_s} W_{rs} L_{rs}}{\sum_{s'} \frac{\alpha_{s'}}{1-\alpha_s} W_{rs'} L_{rs'}} [w_{rs} + l_{rs}] = p_r + x_r,$$

where the last equality follows from equation (B.21). Similarly we can obtain

$$w_r + l_r = \sum_{s'} \frac{\frac{1-\alpha_s}{\alpha_s} R_r K_{rs}}{\sum_{s'} \frac{1-\alpha_{s'}}{\alpha'_s} R_r K_{rs'}} [r_r + k_{rs}] = p_r + x_r,$$

then

$$r_r + k_r = w_r + l_r.$$

Using (B.33) this can be rearranged as

$$w_{rt} - p_{rt} = \alpha_r \left[k_{rt} - l_{rt}\right]. \tag{B.34}$$

We now follow reintroduce the subindices t to characterize the evolution of the capital stock. Log differentiating (B.4) and using (B.33) we obtain

$$k_{rt} - k_{rt-1} = -\frac{1-\alpha_r}{\alpha_r}\left[1 - \beta\left[1-\delta\right]\right]\left[w_{rt-1} - p_{rt-1}\right]. \tag{B.35}$$

Substituting (B.34) and rearranging we get

$$k_{rt} - l_{rt} = b\left[k_{rt-1} - l_{rt-1}\right] - \left[l_{rt} - l_{rt-1}\right],$$

with $b \equiv \alpha_r + [1-\alpha_r]\,\beta\,[1-\delta] < 1$. We can write this as

$$k_{rt} - l_{rt} = -\sum_{\tau=0}^{t-1} b^{\tau}\left[l_{r,t-\tau} - l_{r,t-1-\tau}\right].$$

Finally, using equation (B.34) yields

$$w_{rt} - p_{rt} = -\alpha_r \sum_{\tau=0}^{t-1} b^{\tau}\left[l_{r,t-\tau} - l_{r,t-1-\tau}\right]$$

which in combination with (B.34) gives equation (12). ■

B.2.2 Proof of Proposition 2

No migration We first solve for the evolution of the relative supplies in the short run or when $\nu = 0$. In that case, (B.25) implies

$$l_{rt}^{U} - l_{rt}^{N} = \left[h_t^{U} - h_t^{N}\right] + \left[1-\pi_{M,r}\right]\psi\left[w_{rt}^{U} - w_{rt}^{N}\right].$$

Note that in combination with equation (B.29) this yields

$$l_{rt}^{U} - l_{rt}^{N} = \frac{1}{1 + \left[1-\pi_{M,r}\right]\psi\xi_r}\left[h_t^{U} - h_t^{N}\right].$$

From (B.25) and the fact that $l_{rt} = \lambda_r^{U} l_{rt}^{U} + \lambda_r^{N} l_{rt}^{N}$ it follows that

$$l_{rt} = \lambda_r^{U} h_t^{U} + \pi_{H,r}\psi\left[w_{rt} - p_{rt}\right].$$

The long run We omit the "∞" time subscripts to streamline notation. From equation (B.25) we obtain

$$l_r^{U} - l_r^{N} = \left[h^{U} - h^{N}\right] + \left[\nu\pi_{M,r} + \left[1-\pi_{M,r}\right]\psi\right]\left[w_r^{U} - w_r^{N}\right] - \nu\left[\left[w^{U} - w^{N}\right] - \left[p^{U} - p^{N}\right]\right],$$

Substituting equation (B.29) we obtain

$$l_r^U - l_r^N = \frac{1}{1+[1-\pi_{M,r}]\,\psi\xi_r + \pi_{M,r}\nu\xi_r}\left[\left[h^U - h^N\right] - \nu\left[\left[w^U - w^N\right] - \left[p^U - p^N\right]\right]\right]. \tag{B.36}$$

Plugging the definitions of $\left[w^U - w^N\right]$ and $\left[p^U - p^N\right]$ we obtain

$$w^i - p^i = \sum_{r=1}^{\mathcal{R}-1} \pi_r^i \pi_{M,r}\left[w_r^i - w_r\right] + \sum_{r=1}^{\mathcal{R}-1} \pi_r^i \pi_{M,r}\left[w_r - p_r\right].$$

Substituting equation (B.29)

$$\begin{aligned}
\sum_{r=1}^{\mathcal{R}-1} \pi_r^N \pi_{M,r}\left[w_r^N - w_r\right] &= \sum_{r=1}^{\mathcal{R}-1} \pi_r^N \pi_{M,r}\xi_r\left[1-\lambda_r^N\right]\left[l_r^U - l_r^N\right] \\
\sum_{r=1}^{\mathcal{R}-1} \pi_r^U \pi_{M,r}\left[w_r^U - w_r\right] &= -\sum_{r=1}^{\mathcal{R}-1} \pi_r^U \pi_{M,r}\xi_r\lambda_r^N\left[l_r^U - l_r^N\right].
\end{aligned}$$

Then

$$\left[w^U - w^N\right] - \left[p^U - p^N\right] = -\sum_{r=1}^{\mathcal{R}-1} \pi_r \pi_{M,r}\xi_r\left[l_r^U - l_r^N\right] + \sum_{r=1}^{\mathcal{R}-1}\left[\pi_r^U - \pi_r^N\right]\pi_{M,r}\left[w_r - p_r\right],$$

with $\pi_r \equiv \left[\pi_r^N\left[1-\lambda_r^N\right] + \pi_r^U\lambda_r^N\right]$. In steady state, $k_{rt} = k_{rt-1}$, so equation (B.35) implies $w_{rt} = p_{rt}$. Then, substituting this and equation (B.36) yields

$$\left[w^U - w^N\right] - \left[p^U - p^N\right] = -\frac{\bar{\xi}}{1-\nu\bar{\xi}}\left[h^U - h^N\right].$$

with

$$\begin{aligned}
\bar{\xi} &\equiv \sum_{r'=1}^{\mathcal{R}-1} \pi_r \frac{\pi_{M,r}\xi_r}{1+[1-\pi_{M,r}]\,\psi\xi_r + \pi_{M,r}\nu\xi_r} \\
1-\nu\bar{\xi} &= 1 - \sum_{r'=1}^{\mathcal{R}-1}\pi_r + \sum_{r'=1}^{\mathcal{R}-1}\pi_r\left[\frac{1+[1-\pi_{M,r}]\,\psi\xi_r}{1+[1-\pi_{M,r}]\,\psi\xi_r + \pi_{M,r}\nu\xi_r}\right]
\end{aligned}$$

Finally substituting into (B.36) yields

$$\begin{aligned}
l_r^U - l_r^N &= \left[1+[1-\pi_{M,r}]\,\psi\xi_r + \pi_{M,r}\nu\xi_r\right]^{-1}\left[1-\nu\bar{\xi}\right]^{-1}\left[h^U - h^N\right] \\
&= \left[1+[1-\pi_{M,r}]\,\psi\xi_r + \nu\left[\pi_{M,r}\xi_r - \sum_{r'=1}^{\mathcal{R}-1}\pi_{rr'}\pi_{M,r'}\xi_{r'}\right]\right]^{-1}\left[h^U - h^N\right],
\end{aligned}$$

where $\pi_{rr'} \equiv \pi_{r'}\frac{[1+[1-\pi_{M,r}]\psi\xi_r + \pi_{M,r}\nu\xi_r]}{1+\left[1-\pi_{M,r'}\right]\psi\xi_{r'} + \pi_{M,r'}\nu\xi_{r'}}$.

In a special case where $\xi_r = \xi$ and $\pi_{M,r} = \pi_M$ we obtain

$$1-\nu\bar{\xi} = 1 - \frac{\pi_M\nu\xi}{1+[1-\pi_M]\,\psi\xi + \pi_M\nu\xi}\sum_{r'=1}^{\mathcal{R}-1}\pi_r,$$

and

$$l_r^U - l_r^N = \frac{1}{1 + [1 - \pi_{M_r}]\,\psi\xi + \pi_M \nu \xi \left[1 - \sum_{r'=1}^{\mathcal{R}-1} \pi_r\right]} \left[h^U - h^N\right].$$

Finally, note that

$$\begin{aligned}\left[1 - \sum_{r'=1}^{\mathcal{R}-1} \pi_r\right] &= 1 - \sum_{r'=1}^{\mathcal{R}-1} \left[\pi_r^N \left[1 - \lambda_r^N\right] + \pi_r^U \lambda_r^N\right] \\ &= \sum_{r'=1}^{\mathcal{R}-1} \left[\pi_r^N - \pi_r^U\right] \lambda_r^N \geq 0.\end{aligned}$$

■

B.2.3 Lemmas

We now state and prove two lemmas that are useful for signing some of the objects in Propositions 1 and 2.

Lemma 1 *: $\omega_r < 1$.*

Proof of Lemma 1 Showing that $\omega_r \leq 1$ is equivalent showing that $\sum_o \pi_{ro}^N \lambda_{ro}^N \geq \lambda_r^N$ or

$$\sum_o \left[\pi_{ro}^N - s_{ro}\right] \lambda_{ro}^N \geq 0.$$

Multiplying by $\frac{W_r^N L_r^N}{W_r L_r}$, noting that $W_r^N L_r^N = \sum_o W_{ro}^N L_{ro}^N$ and using the definitions of $\pi_{ro}^N \equiv \frac{W_{ro}^N L_{ro}^N}{W_r^N L_r^N}$, and $s_{ro} \equiv \frac{W_{ro} L_{ro}}{W_r L_r}$ and $\lambda_{ro}^N \equiv \frac{W_{ro}^N L_{ro}^N}{W_{ro} L_{ro}}$ this can be written as

$$\sum_o \left[\pi_{ro}^N - s_{ro}\right] \lambda_{ro}^N = \sum_o \frac{1}{W_r L_r} \frac{W_{ro}^N L_{ro}^N W_{ro}^N L_{ro}^N}{W_{ro} L_{ro}} - \frac{\sum_o W_{ro}^N L_{ro}^N \sum_o W_{ro}^N L_{ro}^N}{[W_r L_r]^2}$$

We will show that this is the weighted variance of $\frac{W_{ro}^N L_{ro}^N}{W_{ro} L_{ro}}$ across occupations. To simplify notation, define $x_o \equiv \frac{W_{ro}^N L_{ro}^N}{W_{ro} L_{ro}}$ and $\omega_o \equiv \frac{W_{ro} L_{ro}}{W_r L_r}$. We can rewrite the expression as

$$\sum_o \omega_o x_o^2 - \left[\sum_o \omega_o x_o\right] \left[\sum_o \omega_o x_o\right] \geq 0.$$

This can also be written as

$$
\begin{aligned}
\sum_o \omega_o x_o^2 - \left[\sum_o \omega_o x_o\right]^2 &= \sum_o \omega_o x_o^2 + \left[\sum_o \omega_o x_o\right]^2 - 2\left[\sum_o \omega_o x_o\right]^2 \\
&= \sum_o \omega_o \left[x_o^2 + \left[\sum_{o'} \omega_{o'} x_{o'}\right]^2 - 2x_o \left[\sum_{o'} \omega_{o'} x_{o'}\right]\right] \\
&= \sum_o \omega_o \left[x_o - \sum_{o'} \omega_{o'} x_{o'}\right]^2
\end{aligned}
$$

which must be positive since it is the sum of positive terms.■

Lemma 2 : $\xi_{rl} > 0$.

Proof of Lemma 2 We need to prove that

$$
\xi_{rl} = \left[1 + [1 - \pi_{M,r}]\, \psi \xi_r + \nu \left[\pi_{M,r} \xi_r - \sum_{r'=1}^{\mathcal{R}-1} \pi_{rr'} \pi_{M,r'} \xi_{r'}\right]\right]^{-1} > 0
$$

where $\pi_{rr'} \equiv \pi_{r'} \frac{1+[1-\pi_{M,r}]\psi\xi_r + \pi_{M,r}\nu\xi_r}{1+\left[1-\pi_{M,r'}\right]\psi\xi_{r'} + \pi_{M,r'}\nu\xi_{r'}}$ and $\pi_r \equiv \left[\pi_r^N \left[1 - \lambda_r^N\right] + \pi_r^U \lambda_r^N\right]$. We start by writing the term in the bracket as

$$
\begin{aligned}
\xi_{rl}^{-1} =& 1 + [1 - \pi_{M,r}]\, \psi \xi_r + \nu \pi_{M,r} \xi_r - \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'} \frac{1 + [1 - \pi_{M,r}]\, \psi \xi_r + \pi_{M,r} \nu \xi_r}{1 + [1 - \pi_{M,r'}]\, \psi \xi_{r'} + \pi_{M,r'} \nu \xi_{r'}} \pi_{M,r'} \xi_{r'} \\
=& [1 + [1 - \pi_{M,r}]\, \psi \xi_r + \nu \pi_{M,r} \xi_r] \left[1 - \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'} \frac{\pi_{M,r'} \xi_{r'}}{1 + [1 - \pi_{M,r'}]\, \psi \xi_{r'} + \pi_{M,r'} \nu \xi_{r'}}\right],
\end{aligned}
$$

Note that $[1 - \pi_{M,r}]\, \psi \xi_r + \nu \pi_{M,r} \xi_r > 0$, so that $[1 + [1 - \pi_{M,r}]\, \psi \xi_r + \nu \pi_{M,r} \xi_r] > 1$. Hence, the first bracket is positive, and the last term second bracket satisfies

$$
\sum_{r'=1}^{\mathcal{R}-1} \pi_{r'} \frac{\pi_{M,r'} \xi_{r'}}{1 + [1 - \pi_{M,r'}]\, \psi \xi_{r'} + \pi_{M,r'} \nu \xi_{r'}} < \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'},
$$

so that

$$
1 - \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'} \frac{\pi_{M,r'} \xi_{r'}}{1 + [1 - \pi_{M,r'}]\, \psi \xi_{r'} + \pi_{M,r'} \nu \xi_{r'}} > 1 - \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'}.
$$

We will now show that $1 - \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'} > 0$. substituting for $\pi_{r'}$ we obtain

$$
\begin{aligned}
1 - \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'} &= 1 - \sum_{r'=1}^{\mathcal{R}-1} \left[\pi_{r'}^{N} \left[1 - \lambda_{r'}^{N} \right] + \pi_{r'}^{U} \lambda_{r'}^{N} \right]. \\
&= 1 - \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'}^{N} + \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'}^{N} \lambda_{r'}^{N} - \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'}^{U} \left[1 - \lambda_{r'}^{U} \right] \\
&= \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'}^{N} \lambda_{r'}^{N} + \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'}^{U} \lambda_{r'}^{U} - 1.
\end{aligned}
$$

Finally, note that

$$
\sum_{r'=1}^{\mathcal{R}-1} \pi_{r'}^{N} \lambda_{r'}^{N} + \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'}^{U} \lambda_{r'}^{U} = \sum_{r'=1}^{\mathcal{R}-1} \frac{W_{r'}^{N} L_{r'}^{N}}{\sum_r W_r^N L_r^N} \frac{W_{r'}^{N} L_{r'}^{N}}{W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U}} + \sum_{r'=1}^{\mathcal{R}-1} \frac{W_{r'}^{U} L_{r'}^{U}}{\sum_r W_r^U L_r^U} \frac{W_{r'}^{U} L_{r'}^{U}}{W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U}}.
$$

The first term satisfies[21]

$$
\begin{aligned}
\sum_{r'=1}^{\mathcal{R}-1} \frac{W_{r'}^{N} L_{r'}^{N}}{\sum_r W_r^N L_r^N} \frac{W_{r'}^{N} L_{r'}^{N}}{W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U}} &= \left[\sum_{r'=1}^{\mathcal{R}-1} \frac{\left[W_{r'}^{N} L_{r'}^{N} \right]^2}{\left[W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U} \right]^2} \frac{W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U}}{\sum_r W_r^N L_r^N + W_r^U L_r^U} \right] \frac{\sum_r W_r^N L_r^N + W_r^U L_r^U}{\sum_r W_r^N L_r^N} \\
&\geq \frac{\sum_{r'=1}^{\mathcal{R}-1} W_{r'}^{N} L_{r'}^{N}}{\sum_r W_r^N L_r^N + W_r^U L_r^U} \frac{\sum_{r'=1}^{\mathcal{R}-1} W_{r'}^{N} L_{r'}^{N}}{\sum_r W_r^N L_r^N + W_r^U L_r^U} \frac{\sum_r W_r^N L_r^N + W_r^U L_r^U}{\sum_r W_r^N L_r^N} = \frac{\sum_{r'=1}^{\mathcal{R}-1} W_{r'}^{N} L_{r'}^{N}}{\sum_{r'} W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U}}
\end{aligned}
$$

Similarly, the second term satisfies

$$
\sum_{r'=1}^{\mathcal{R}-1} \frac{W_{r'}^{U} L_{r'}^{U}}{\sum_r W_r^U L_r^U} \frac{W_{r'}^{U} L_{r'}^{U}}{W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U}} \geq \frac{\sum_{r'=1}^{\mathcal{R}-1} W_{r'}^{U} L_{r'}^{U}}{\sum_{r'} W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U}}.
$$

Putting these two statements together we obtain

$$
\sum_{r'=1}^{\mathcal{R}-1} \pi_{r'}^{N} \lambda_{r'}^{N} + \sum_{r'=1}^{\mathcal{R}-1} \pi_{r'}^{U} \lambda_{r'}^{U} \geq \frac{\sum_{r'=1}^{\mathcal{R}-1} W_{r'}^{N} L_{r'}^{N}}{\sum_{r'} W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U}} + \frac{\sum_{r'=1}^{\mathcal{R}-1} W_{r'}^{U} L_{r'}^{U}}{\sum_{r'} W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U}} = 1,
$$

which concludes the proof.■

[21] To see this, define $x_{r'} \equiv \frac{W_{r'}^{N} L_{r'}^{N}}{W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U}}$ and $\omega_{r'} \equiv \frac{W_{r'}^{N} L_{r'}^{N} + W_{r'}^{U} L_{r'}^{U}}{\sum_r W_r^N L_r^N + W_r^U L_r^U}$, and note that $\sum_{r'} \omega_{r'} x_{r'}^2 - \left[\sum_{r'} \omega_{r'} x_{r'} \right] \left[\sum_{r'} \omega_{r'} x_{r'} \right] \geq 0$ is the formula for a weighted variance.

C Quantification

C.1 Formulation in changes

Following the standard approach of Dekle, Eaton, and Kortum (2008) we express the model in gross proportional changes. For any variable x, let $\hat{x}_t \equiv \frac{x_t}{x_0}$ denote the cumulative change between period t and the initial equilibrium. We can then write the equations in changes as follows.

Regional prices:

$$\hat{P}_{rt} = \prod_s \hat{P}_{rst}^{\gamma_s}. \tag{C.1}$$

Regional population shares for each type i and $r \in \mathcal{R} - 1$:

$$\hat{\pi}^i_{rt} = \frac{\left[\hat{\Upsilon}^i_{rt}\right]^{\nu}}{\sum_{r' \in \mathcal{R}-1} \pi^i_{r}\left[\hat{\Upsilon}^i_{rt}\right]^{\nu}}. \tag{C.2}$$

Share of market workers for $r \in \mathcal{R} - 1$:

$$\hat{\pi}^i_{M,rt} = \frac{\left[\frac{\hat{W}^i_{rt}}{\hat{P}_{rt}}\right]^{\psi}}{\pi^i_{M,r}\left[\frac{\hat{W}^i_{rt}}{\hat{P}_{rt}}\right]^{\psi} + 1 - \pi^i_{M,r}}. \tag{C.3}$$

Expected consumption value of living in region r:

$$\left[\hat{\Upsilon}^i_{rt}\right]^{\psi} = \pi^i_{M,r}\left[\frac{\hat{W}^i_{rt}}{\hat{P}_{rt}}\right]^{\psi} + 1 - \pi^i_{M,r}. \tag{C.4}$$

Occupation shares, regional wage changes, and labor supplies are:

$$\hat{\pi}^i_{rot} = \frac{\left[\widehat{W}^i_{rot}\right]^{\theta+1}}{\sum_{o'} \pi^i_{ro'}\left[\widehat{W}^i_{ro't}\right]^{\theta+1}} \tag{C.5}$$

$$\left[\widehat{W}^i_{rt}\right]^{1+\theta} = \sum_o \pi^i_{ro}\left[\widehat{W}^i_{rot}\right]^{\theta+1} \tag{C.6}$$

$$\hat{L}^i_{rot} = \hat{H_t}^i \hat{\pi}^i_{rt}\ \hat{\pi}^i_{M,rt}\ \hat{Z^i_{rot}}\left[\hat{\pi}^i_{rot}\right]^{\frac{\theta}{1+\theta}}. \tag{C.7}$$

Consumption by type i households of sectoral good s is

$$\hat{P}_{rst}\hat{C}^i_{rst} = \hat{H}^i_t \hat{\pi}^i_{rt}\hat{\pi}^i_{M,rt}\hat{W}^i_{rt}. \tag{C.8}$$

Labor, capital, and intermediate demands are

$$\hat{W}_{rst}\hat{L}_{rst} = \hat{P}^y_{rst}\hat{Y}_{rst}. \tag{C.9}$$

$$\hat{R}_{rt}\hat{K}_{rst} = \hat{P}^{y}_{rst}\hat{Y}_{rst}. \tag{C.10}$$

$$\hat{P}_{rs't}\hat{M}_{rs'st} = \hat{P}^{y}_{rst}\hat{Y}_{rst}. \tag{C.11}$$

Unit cost of variety from region r:

$$\hat{P}^{y}_{rst} = \left[\hat{R}^{\alpha_s}_{rt}\hat{W}^{1-\alpha_s}_{rst}\right]^{\kappa_s}\left[\Pi_{s'}\hat{P}^{\gamma_{s's}}_{rs't}\right]^{1-\kappa_s}, \tag{C.12}$$

where the change in the cost of sector s labor bundle in region r is

$$\hat{W}_{rst} = \left[\sum_{o}\phi_{rso}\left[\hat{W}_{rot}\right]^{1-\eta}\right]^{\frac{1}{1-\eta}}, \tag{C.13}$$

with $\phi_{rso} \equiv \frac{W_{ro}L_{rso}}{W_{rs}L_{rs}}$. The demand for labor of each occupation in each sector-region is:

$$\hat{L}_{rsot} = \left[\frac{\hat{W}_{rot}}{\hat{W}_{rst}}\right]^{-\eta}\hat{L}_{rst}. \tag{C.14}$$

Demands for native and foreign-born labor in occupation o in region r are:

$$\hat{L}^{N}_{rot} = \left[\frac{\hat{W}^{N}_{ro}}{\hat{W}_{rot}}\right]^{-\epsilon}\hat{L}_{rot}, \tag{C.15}$$

$$\hat{L}^{F}_{rot} = \left[\frac{\hat{W}^{F}_{rot}}{\hat{W}_{rot}}\right]^{-\epsilon}\hat{L}_{rot}, \tag{C.16}$$

where the cost of labor bundle in occupation o index in region r:

$$\hat{W}_{rot} = \left[\lambda^{N}_{ro}\left[\hat{W}^{N}_{rot}\right]^{1-\epsilon} + \left[1-\lambda^{N}_{ro}\right]\left[\hat{W}^{F}_{rot}\right]^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}, \tag{C.17}$$

with $\lambda^{i}_{ro} \equiv \frac{W^{i}_{ro}L^{i}_{ro}}{W_{ro}L_{ro}}$. Demands for authorized and unauthorized workers are

$$\hat{L}^{A}_{rot} = \left[\frac{\hat{W}^{A}_{rot}}{\hat{W}^{F}_{rot}}\right]^{-\sigma}\hat{L}^{F}_{rot}, \tag{C.18}$$

$$\hat{L}^{U}_{rot} = \left[\frac{\hat{W}^{U}_{rot}}{\hat{W}^{F}_{rot}}\right]^{-\sigma}\hat{L}^{F}_{rot}, \tag{C.19}$$

where

$$\hat{W}^{F}_{rot} = \left[\frac{\lambda^{A}_{ro}}{\lambda^{A}_{ro}+\lambda^{U}_{ro}}\left[\hat{W}^{A}_{rot}\right]^{1-\sigma} + \frac{\lambda^{U}_{ro}}{\lambda^{A}_{ro}+\lambda^{U}_{ro}}\left[\hat{W}^{U}_{rot}\right]^{1-\sigma}\right]^{\frac{1}{1-\sigma}}. \tag{C.20}$$

Demand by region r for region r' variety in sector s

$$\hat{Y}_{r'rst} = \left[\frac{\hat{P}^{y}_{r'st}}{\hat{P}_{rst}}\right]^{-\chi} \hat{X}_{rst}, \tag{C.21}$$

where the price change of sector s bundle in region r is

$$\hat{P}_{rst} = \left[\sum_{r'} \varpi_{r'rs} \left[\hat{P}^{y}_{r'st}\right]^{1-\chi}\right]^{\frac{1}{1-\chi}}, \tag{C.22}$$

with $\varpi_{r'rs} \equiv \frac{P^{y}_{r's} Y_{r'rs}}{P_{rs} X_{rs}}$.

Market clearing for the labor bundle in occupation o:

$$\hat{L}_{rot} = \sum_{s} \frac{\phi_{rso} s_{rs}}{\sum_{s'} \phi_{rs'o} s_{rs'}} \hat{L}_{rsot}, \tag{C.23}$$

with $s_{rs} \equiv \frac{W_{rs} L_{rs}}{\sum_{s'} W_{rs'} L_{rs'}}$. Market clearing for goods:

$$\hat{Y}_{rst} = \sum_{r'} \varpi^{x}_{rr'st} \hat{Y}_{rr'st}, \tag{C.24}$$

where $\varpi^{x}_{rr's} \equiv \frac{P^{y}_{rs} Y_{rr's}}{P^{y}_{rs} Y_{rs}}$ is the share of exports to r' in total production of region r, sector s. Market clearing for capital implies

$$\hat{K}_{rt} = \sum_{s} \frac{K_{rs}}{K_{r}} \hat{K}_{rst}. \tag{C.25}$$

Change in absorption

$$\widehat{P}_{rst} \widehat{X}_{rst} = \left[1 - s^{G}_{rs}\right] \left[s^{L}_{rs} \sum_{i} \lambda^{i}_{r} \widehat{P}_{rt} \widehat{C}^{i}_{rt} + s^{K}_{rs} \hat{R}_{r,t} \hat{K}_{r,t} + \sum_{s'} s^{M}_{rss'} \widehat{P}^{y'}_{rs't} \widehat{Y}_{st}\right] + \widehat{P}_{rst} \widehat{G}_{rst} s^{G}_{rs}, \tag{C.26}$$

with

$$s^{G}_{rs} \equiv \frac{P_{rs} G_{rs}}{P_{rs} X_{rs}}$$

$$s^{L}_{rs} \equiv \frac{\gamma_s \sum_{s'} \kappa_{s'} \left[1 - \alpha_{s'}\right] s^{y}_{rs'}}{\gamma_s \sum_{s'} \kappa_{s'} s^{y}_{rs'} + \sum_{s'} \left[1 - \kappa_{s'}\right] \gamma_{ss'} s^{y}_{rs'}} \tag{C.27}$$

$$s^{K}_{rs} \equiv \frac{\gamma_s \sum_{s'} \kappa_{s'} \alpha_{s'} s^{y}_{rs'}}{\gamma_s \sum_{s'} \kappa_{s'} s^{y}_{rs'} + \sum_{s'} \left[1 - \kappa_{s'}\right] \gamma_{ss'} s^{y}_{rs'}} \tag{C.28}$$

$$s^{M}_{rss'} \equiv \frac{\left[1 - \kappa_{s'}\right] \gamma_{ss'} s^{y}_{rs'}}{\gamma_s \sum_{s'} \kappa_{s'} s^{y}_{rs'} + \sum_{s'} \left[1 - \kappa_{s'}\right] \gamma_{ss'} s^{y}_{rs'}}. \tag{C.29}$$

The capital stock evolves according to

$$\hat{K}_{r,t+1} = \beta \left[\frac{\hat{R}_{r,t}}{\hat{P}_{r,t}} \left[\frac{R_{r,0}}{P_{r,0}}\right] + 1 - \delta\right] \hat{K}_{r,t},$$

where $\frac{R_{r,0}}{P_{r,0}}$ is pinned down by our assumption that the economy starts in steady state:

$$\frac{R_{r,0}}{P_{r,0}} = \frac{1}{\beta} - (1-\delta).$$

For $\mathcal{R}$, $\pi_{\mathcal{R}} = 1$ and $\pi_{M,\mathcal{R}} = 1$, so $\hat{\pi}_{\mathcal{R}}$ and $\hat{\pi}_{M,\mathcal{R}}$ will trivially update to 1, and $\left[\hat{\Upsilon}_{\mathcal{R}t}\right]^{\psi} = \left[\frac{\hat{W}^k_{\mathcal{R}t}}{\hat{P}_{\mathcal{R}t}}\right]^{\psi}$, but this update is inconsequential for $\mathcal{R}$ as households make no migration decisions. Note that expression (C.7) covers $\mathcal{R}$, because for this region $\hat{\pi}^i_{\mathcal{R}} = 1$ and $\hat{\pi}^i_{M,\mathcal{R}} = 1$, and (C.8) covers $\mathcal{R}$. For $\mathcal{R}$, there is only $\hat{L}_{rot}$ and $\hat{W}_{rot}$, and expressions for $\hat{W}^i_{rot}$ are unnecessary.

These equations, given the initial condition $\hat{K}_{r,1} = 1$, can be solved numerically following a set of shocks to the population of foreign-born $\hat{H}^i_t$ using the algorithm described next.

C.2 Iteration algorithm

We solve the system of equations for any t given K_{rt} in all regions and the sequence $\hat{H}^i_t$, given $\hat{\pi}^i_{rt} = \frac{\pi^i_{rt}}{\pi^i_{r0}}$. We start from $t = 1$ and move forward.

i. For $t = 1$, set $\hat{K}_{r1} = 1$ and $\hat{\pi}^i_{rt-1} = 1$. For $t > 1$ set

$$\frac{R_{r,0}}{P_{r,0}} = \frac{1}{\beta} - 1 + \delta.$$

and

$$\hat{K}_{r,t} = \beta \left[\frac{\hat{R}_{r,t-1}}{\hat{P}_{r,t-1}} \left[\frac{R_{r,0}}{P_{r,0}}\right] + 1 - \delta\right] \hat{K}_{r,t-1}.$$

ii. Guess occupation-group-specific wage changes $\left\{\hat{W}^i_{rot}\right\}_{ro}^{i\in\{N,A,U\}}$ and rates of return $\left\{\hat{R}_{rt}\right\}_r$.

iii. Compute wages and wage aggregates

$$\hat{W}^F_{rot} = \left[\mu_{ro}\left[\hat{W}^A_{rot}\right]^{1-\sigma} + [1-\mu_{ro}]\left[\hat{W}^U_{rot}\right]^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

$$\hat{W}_{rot} = \left[\lambda_{ro}\left[\hat{W}^D_{rot}\right]^{1-\epsilon} + [1-\lambda_{ro}]\left[\hat{W}^F_{rot}\right]^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$$

$$\hat{W}_{rst} = \left[\sum_o \phi_{rso}\left[\hat{W}_{rot}\right]^{1-\eta}\right]^{\frac{1}{1-\eta}}$$

$$\left[\widehat{W}^k_{rt}\right]^{1+\theta} = \sum_o \pi^k_{ro}\left[\widehat{W}^k_{rot}\right]^{\theta+1}.$$

iv. Using the guess for $\{\hat{W}_{rst}\}_{rs}$ and $\{\hat{R}_{rt}\}_{rs}$ solve the system

$$\begin{aligned}
\hat{P}^{y}_{rst} &= \hat{W}^{[1-\alpha_s]\kappa_s}_{rst}\hat{R}^{\alpha_s\kappa_s}_{rt}\hat{P}^{1\kappa_s}_{Msrt} \\
\hat{P}^{1-\chi}_{rst} &= \left[\sum_{r'}\omega_{r'rs'}\left[\hat{P}^{y}_{r's't}\right]^{1-\chi}\right] \\
\hat{P}_{rt} &= \prod_{s'}\hat{P}^{\gamma_{s'}}_{rs't} \\
\hat{P}_{Msrt} &= \prod_{s'}\hat{P}^{\gamma_{s's}}_{rst}.
\end{aligned}$$

Compute $\hat{P}_{rt}$ and $\hat{\omega}_{rr's't} = \frac{\left[\hat{P}^{y}_{rst}\right]^{1-\chi}}{\hat{P}^{1-\chi}_{r's't}}$.

v. Compute changes in worker shares, labor supplies and consumption

$$\begin{aligned}
\left[\hat{\Upsilon}^{i}_{rt}\right]^{\psi} &= \pi^{i}_{M,r}\left[\frac{\hat{W}^{i}_{rt}}{\hat{P}_{rt}}\right]^{\psi} + 1 - \pi^{i}_{M,r} \\
\hat{\pi}^{i}_{M,rt} &= \frac{\left[\frac{\hat{W}^{i}_{rt}}{\hat{P}_{rt}}\right]^{\psi}}{\left[\hat{\Upsilon}^{i}_{rt}\right]^{\psi}} \\
\hat{\pi}^{i}_{rt-1} &= \frac{\left[\hat{\Upsilon}^{i}_{rt}\right]^{\nu}}{\sum_{r'\in\mathcal{R}-1}\pi^{i}_{r}\left[\hat{\Upsilon}^{i}_{rt}\right]^{\nu}} \\
\widehat{\pi}^{i}_{rot} &= \frac{\left[\widehat{W}^{i}_{rot}\right]^{\theta+1}}{\left[\widehat{W}^{i}_{rt}\right]^{\theta+1}}.
\end{aligned}$$

ROW can be anything at this point. The change in consumption in US regions is

$$\hat{P}_{rt}\hat{C}_{rt} = \hat{H}^{i}_{USt}\hat{\pi}^{i}_{rt-1}\hat{\pi}^{i}_{M,rt}\hat{W}^{i}_{rt}.$$

The change in ROW consumption is

$$\hat{P}_{\mathcal{R}t}\hat{C}^{i}_{\mathcal{R}t} = \hat{H}^{i}_{\mathcal{R}t}\hat{W}^{i}_{\mathcal{R}t}.$$

The change in total consumption by workers is

$$\widehat{P}_{rt}\widehat{C}_{rt} = \sum_{i}\lambda^{i}_{r}\widehat{P}_{rt}\widehat{C}^{i}_{rt}.$$

The change in the labor supplies in US is

$$\hat{L}^{i}_{rot} = \hat{H}^{i}_{US}\hat{\pi}^{i}_{rt-1}\ \hat{\pi}^{i}_{M,rt}\ \left[\hat{\pi}^{i}_{rot}\right]^{\frac{\theta}{1+\theta}}.$$

The change in the labor supplies in ROW is

$$\hat{L}^{i}_{\mathcal{R}ot} = \hat{H}^{i}_{\mathcal{R}t}\left[\hat{\pi}^{i}_{\mathcal{R}ot}\right]^{\frac{\theta}{1+\theta}}.$$

vi. Solve the system

$$\hat{P}^{y}_{rs't}\hat{Y}_{rs't} = \sum_{r'} \varpi^{x}_{rr's'}\hat{\varpi}_{rr's't}\hat{P}_{r's't}\hat{X}_{r's't}$$

$$\hat{R}_{r,t}\hat{K}_{r,t} = \sum_{s} \frac{\kappa_s \alpha_s s^{y}_{rs}}{\sum_{s'} \kappa_s \alpha_{s'} s^{y}_{rs'}} \hat{P}^{y}_{rst}\hat{Y}_{rst}$$

$$\widehat{P}_{rst}\widehat{X}_{rst} = \left[1 - s^{G}_{rs}\right] \left[s^{L}_{rs} \sum_{i} \lambda^{i}_{r} \widehat{P}_{rt} \widehat{C}^{i}_{rt} + s^{K}_{rs} \hat{R}_{r,t}\hat{K}_{r,t} + \sum_{s'} s^{M}_{rss'} \widehat{P}^{y'}_{rs't} \widehat{Y}_{st}\right] + \widehat{P}_{rst}\widehat{G}_{rst}s^{G}_{rs}.$$

vii. Compute labor demands and update guess

$$\hat{L}_{rst} = \frac{\hat{P}^{y}_{rst}\hat{Y}_{rst}}{\hat{W}_{rst}}$$

$$\hat{L}_{rsot} = \left[\frac{\hat{W}_{rot}}{\hat{W}_{rst}}\right]^{-\eta} \hat{L}_{rst}$$

$$\hat{L}_{rot} = \sum_{s} \frac{\phi_{rso}s_{rs}}{\sum_{s'} \phi_{rs'o}s_{rs'}} \hat{L}_{rsot}.$$

viii. Set new guesses:

$$\hat{W}^{N}_{rot} = \hat{W}_{rot} \left[\frac{\hat{L}^{N}_{rot}}{\hat{L}_{rot}}\right]^{-\frac{1}{\epsilon}}$$

$$\hat{W}^{A}_{rot} = \hat{W}^{F}_{rot} \left[\frac{\hat{L}^{A}_{rot}}{\hat{L}_{rot}} \left[\frac{\hat{W}^{F}_{rot}}{\hat{W}_{rot}}\right]^{\epsilon}\right]^{-\frac{1}{\sigma}}$$

$$\hat{W}^{U}_{rot} = \hat{W}^{F}_{rot} \left[\frac{\hat{L}^{U}_{rot}}{\hat{L}_{rot}} \left[\frac{\hat{W}^{F}_{rot}}{\hat{W}_{rot}}\right]^{\epsilon}\right]^{-\frac{1}{\sigma}}$$

and

$$\hat{R}_{rt} = \frac{\hat{R}_{r,t}\hat{K}_{r,t}}{\hat{K}_{r,t}}.$$

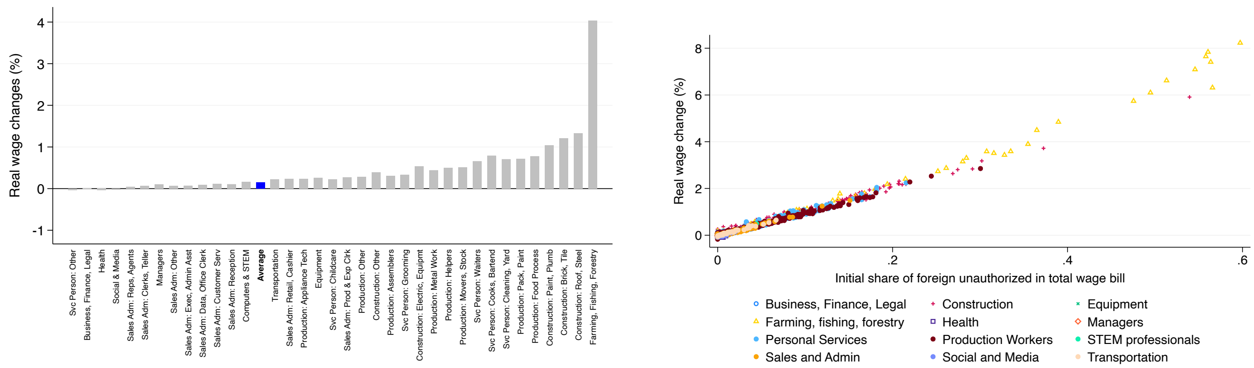
ix. Repeat steps 2-8 to convergence.

x. Move to $t+1$ by going back to step 1.

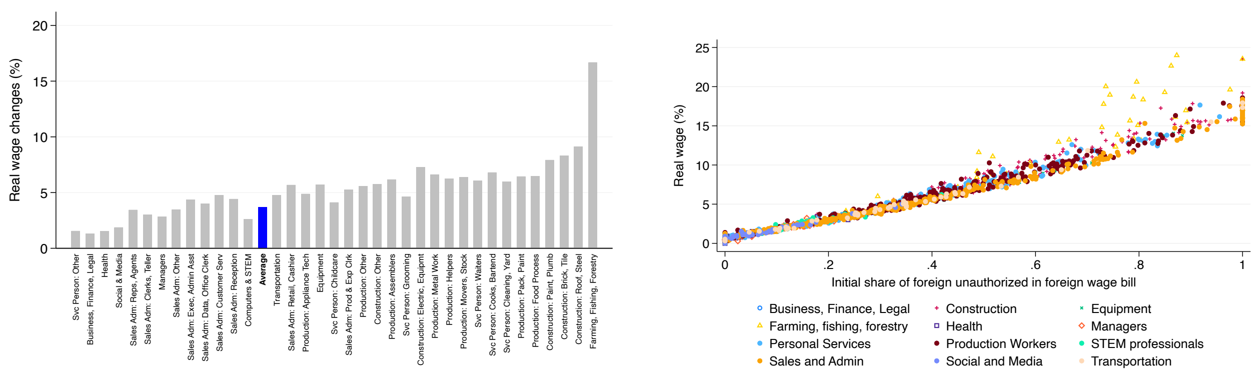
C.3 Additional results

Figure A1: Changes in real wages across occupations, the short run

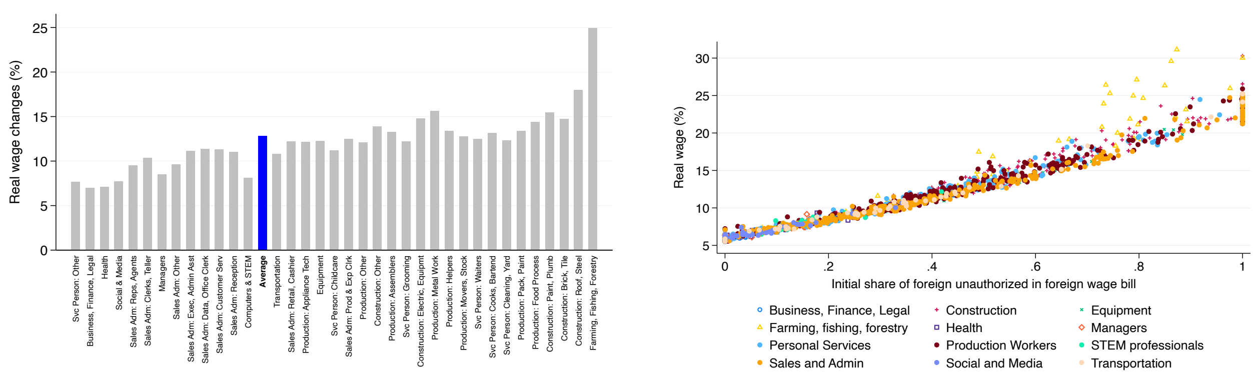
Panel A: Natives



Panel B: Foreign Authorized

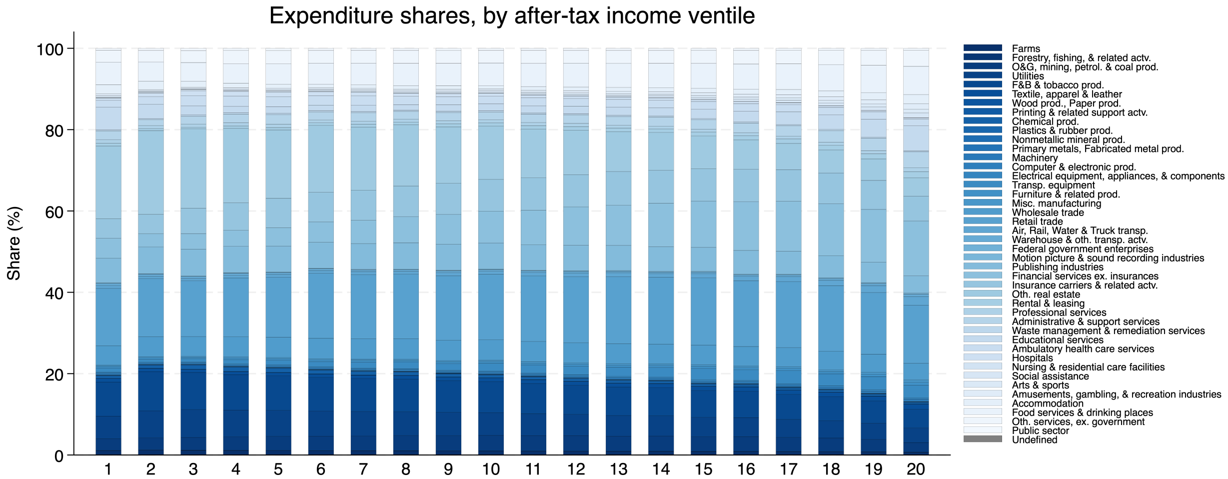


Panel C: Foreign Unauthorized



Notes: This figure plots the short-run real wage changes of three types of workers, for each occupation, following a 50% reduction in unauthorized workers nationally. The left panels plot the nationwide changes, and the right panels plot the occupation-region changes against the share of foreign unauthorized workers in the total wage bill (top panel) or the share of unauthorized workers in the foreign wage bill (middle and bottom). For the bar graphs, occupations are sorted by the initial share of foreign unauthorized.

Figure A2: Sectoral expenditure shares by income percentile

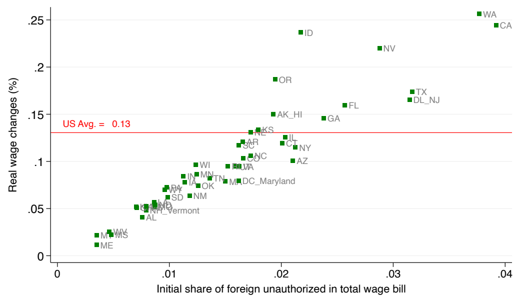


Notes: This figure plots the expenditure shares on the different sectors by 5% income bins (1-20).

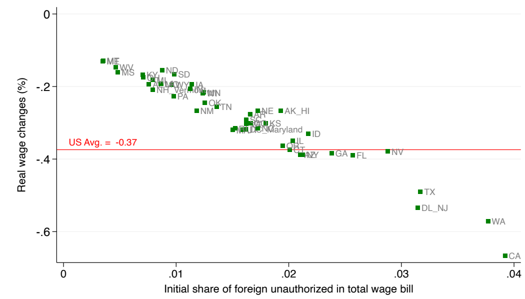
Figure A3: Sensitivity: $\chi = 7$

Panel A: Real wages, natives

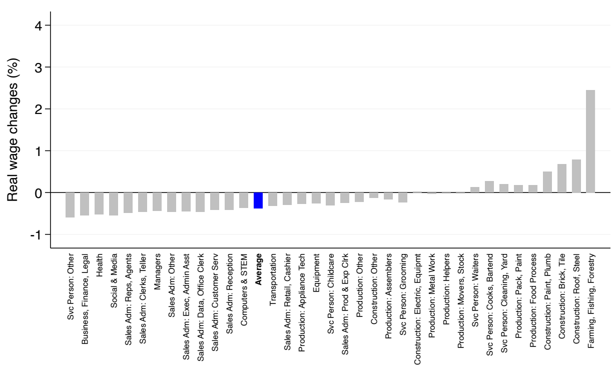
Short run

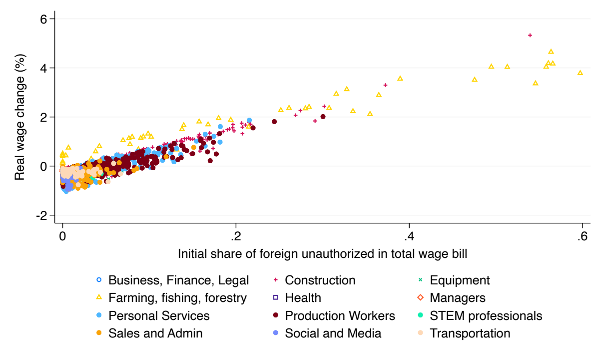


Long run



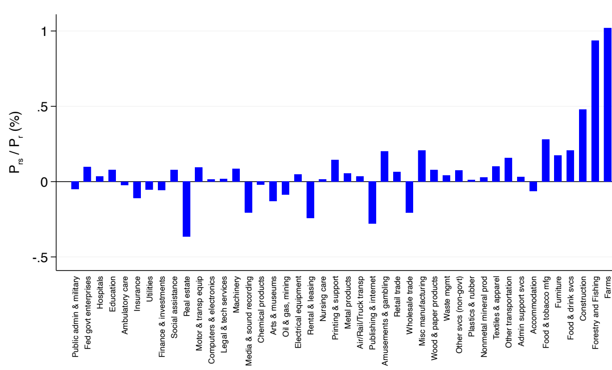
Panel B: Real wages by occupation in the long run, natives



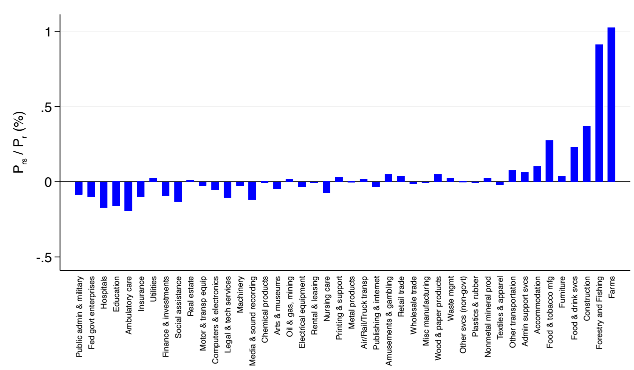


Panel C: Relative consumer prices

Short run



Long run



Notes: This figure plots wages and prices following a 50% reduction in unauthorized workers nationally, under a higher trade elasticity ($\chi = 7$). Panel A plots native regional wages. Panel B plots native wages by occupation in the long run. Panel C plots the consumer prices.