Skilled Immigration, Offshoring, and Trade*

Mishita Mehra†
Grinnell College

Daisoon Kim‡
North Carolina State University

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Abstract

This paper studies the impact of skilled immigration policy changes in the U.S. using a dynamic general equilibrium model with skilled migration, offshore labor hiring, and intermediate input trade. The novel feature of the model is that it explicitly accounts for firms' response in offshore labor hiring following skilled immigration policy changes. We evaluate the impact of a stricter immigration policy and show that the offshoring channel is important for the welfare impacts. The calibrated model that matches the U.S. economy suggests that we would overestimate the welfare gain to skilled domestic workers after a 10 percent immigration cap reduction by approximately 18 percent if we ignore the offshoring channel. The paper highlights the importance of considering the interactions between immigration, offshoring, and trade, when designing immigration policy changes.

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†Grinnell College, Grinnell, Iowa, 50112 email: mehramis@grinnell.edu
‡North Carolina State University, Raleigh, North Carolina 27695 email: dkim29@ncsu.edu

1 Introduction

There has been a significant increase in skilled migration to the U.S. in recent years, which has led to growing debates on immigration policy and increasing concerns about wages and employment of domestic workers.[1] One of the arguments for a stricter skilled immigration policy is that it would lead to higher wages and employment gains for native skilled workers. However, what is often ignored in these discussions is firms' response to immigration policy changes. Firms play a crucial role in the current H1-B visa policy, which is the dominant entry route for foreign skilled workers in the U.S.[2] Multiple surveys indicate that the immigration policy imposed cap and administrative procedures impose frictions and incentivize firms to increase their offshoring activities by sending foreign workers to offshore affiliates and/or hiring foreign skilled labor in these affiliates.[3] Therefore, the design of immigration policy in the U.S. requires models with systemic links between skilled immigrants and offshore workers. However, most of the debates and literature surrounding the impacts of skilled immigration policy changes ignore this offshoring channel even though it is potentially important for how skilled immigration policy changes affect wages, employment, and domestic households' welfare.

This study aims to highlight this important caveat — policies that restrict skilled immigration may not affect wages as much as one would expect. Instead, firms can respond through hiring skilled labor at offshore locations or through importing skill-intensive intermediate goods. Motivated by this, we build a dynamic general equilibrium model that includes a channel where firms can adjust their offshore labor hiring following immigration policy changes. Our main goal is to quantify the relevance of the offshoring channel when evaluating the welfare impacts of skilled immigration policy changes on skilled and unskilled domestic workers. We also aim to shed more light on the channels that link skilled immigration, offshore labor hiring, and intermediate input trade.

To this end, we first document some trends that highlight the growth of trade and offshoring within the Professional, Scientific, and Technical Services sector as this sector constitutes the bulk of skilled foreign-born workers hired in the U.S. We then build a two-country (Home and Foreign), two-sector (intermediate and final goods), dynamic general equilibrium model with offshoring, skilled immigration, and intermediate inputs trade. In the baseline model, firms in the intermediate goods sector at Home produce differentiated goods using domestic and immigrant skilled labor and Foreign

[1] Skilled foreign-born now constitute more than 17% of the skilled labor force in the U.S. (Current Population Survey). Among all foreign-born individuals, those with at least a bachelor's degree witnessed the sharpest increase (42%) during the 2004 – 2016 period. The corresponding increase for the native-born in the same skill group was 26% in the U.S. According to Kerr, Kerr, Özden and Parsons (2016), skilled and low-skilled workers' global immigration increased nearly 130 and 40 percent, respectively, from 1990 to 2010.

[2] See Appendix A for an overview of the H1-B policy and the quota.

[3] For instance, according to a survey by Anderson (2012), for the National Venture Capital Association, 43% of the companies said that the lack of H-1B visas influenced the company's decisions to place or hire more personnel in facilities located outside the United States. In another survey (Slaughter 2016), 77% of firms responded that "skilled positions unfilled for more than 30 days harm their operations and 71% thus say that if it became too difficult to find qualified talent in America, they would consider relocating". According to a GAO (2011) report, in years when firms did not receive approvals for their H-1B petitions, most of the large, multinational firms reported that they were generally able to hire their preferred candidates by sending the candidate to work in an overseas office, but they had to incur additional costs to do this.

skilled labor hired in offshore affiliates. The domestic skilled labor supply is inelastic. These firms optimally choose the amount of skilled labor to hire, subject to an immigration policy-imposed cap, a hiring cost for each worker, and an exogenous probability of return to Foreign. The immigration cap is binding in the model, and firms are allocated a fraction of their immigrant worker demand.[4] The emigration from Foreign is determined by firm labor demand in the Home country.[5] The immigration cap restricts the amount of Foreign skilled labor that firms can hire domestically and increases the cost of hiring skilled workers. However, firms can also hire Foreign skilled workers in an already existing offshore affiliate in Foreign. To produce offshore, firms have to pay a per-period fixed cost in order to maintain their relationship with the Foreign affiliate. Firms in our model hire labor offshore till the marginal costs of domestic and offshore production are equalized. The model features an increase in offshoring at the intensive margin (increase in labor hired in existing affiliates) rather than an increase in the number of Foreign offshore affiliates (extensive margin). By hiring labor offshore, firms are able to hire more skilled workers and overcome some of the frictions imposed by skilled immigration policy. Firms in the final goods sector produce output using unskilled labor and intermediate goods produced by domestic and foreign non-affiliated firms.

We first solve the model analytically and highlight channels that affect offshore labor hiring and intermediate trade. Then, to solve the model numerically, we calibrate the main parameters in the Home country that pertain to immigration policy, labor markets, trade, and offshoring at Home to match the U.S. economy during the 2004 – 2017 period. We also calibrate parameters related to the Foreign economy's labor markets to match data from India. We show that the calibrated model is broadly consistent with recent data trends in offshore labor hiring. We then use the calibrated model to conduct counterfactual policy changes in immigration and trade policies in the domestic economy.

Our main counterfactual exercise quantifies the impact of a 10 percent immigration cap reduction in order to analyze the impact of a stricter immigration policy. A reduction in the skilled immigration cap reduces skilled labor available at Home and puts pressure on domestic skilled wages to increase. This incentivizes domestic firms to substitute for Foreign labor through an increase in offshore labor hiring. Due to iceberg trade costs and lower productivity in Foreign, firms do not entirely substitute immigrant labor with offshore labor. Therefore, the increase in the labor hired offshore is less than the decline in immigrant labor hired domestically, and the total output produced by the intermediate sector at Home decreases, leading to lower firm profits.

The results emphasize the importance of accounting for the offshoring activities of domestic firms after an immigration policy change. When we do not account for the adjustment in offshore labor hiring after the immigration cap decline, wages of domestic skilled workers rise by more compared to the case where we account for the adjustment in offshore labor hiring. Since firms can

[4]This mimics the current H1-B policy as when the cap binds, firms are allocated workers according to a lottery. The H1-B cap has been binding since 2004.

[5]This assumption is realistic due to the significant wage differences between OECD countries like the U.S. and developing countries like India. If hired, there is a strong incentive for a Foreign skilled worker to join the Home labor force. Empirically, Clemens (2013) estimates a six-fold increase in salary for skilled workers who migrate to the U.S.

partly substitute immigrant skilled labor with offshore workers (that are now relatively cheaper due to more skilled labor available in Foreign), the wages of skilled workers increase by less at Home. This is important for welfare calculations. The welfare gain to domestic skilled workers due to a wage increase following a 10% immigration cap reduction is 18.4% higher when we ignore the offshoring channel.

Moreover, the offshoring channel is important for how changes in immigration impact trade. Our framework with skilled immigration, offshore labor hiring, and trade in intermediate inputs includes two channels of imports from the Foreign economy. First, part of the domestic intermediate firm's output is produced offshore and is imported back to the Home country. Second, domestic final goods firms also import intermediate goods from non-affiliated foreign intermediate firms. A decrease in skilled immigration has two opposing effects on imports. On the one hand, there is an increase in offshore labor hiring, which increases output produced in the offshore affiliates, and therefore imports from affiliated firms increase. On the other hand, a lower immigrant stock in the domestic economy tends to decrease the import of intermediate inputs from non-affiliated firms.[6]

Our framework highlights that firms' adjustment in offshore labor hiring following an immigration policy change matters for the quantitative and qualitative impacts in the domestic economy. Therefore, our results indicate that it is essential to consider the general equilibrium relationships between immigration, offshoring, and trade when studying the impact of immigration and trade policy changes. This is the paper's main contribution — we study the interactions between skilled immigration, offshoring, and trade in intermediate inputs, in a dynamic general equilibrium model with a skilled immigration policy setup that mimics the U.S. and a focus on the skilled services sector.

This paper is organized as follows. In the next section, we discuss the related literature. Section 3 documents some trends that motivate our focus on skilled immigration and offshoring in the skilled services sector. Section 4 introduces our baseline model. Section 5 describes some relationships obtained from the model's analytical solution, and in Section 6, we present the calibration for the numerical solution. Section 7 compares our model predictions with trends in the data. We then discuss the main welfare results and the underlying mechanisms in Section 8. The last section concludes.

2 Related Literature

This paper contributes to studies that measure the welfare gains from lowering barriers to labor mobility, for instance, Urrutia (1998), Klein and Ventura (2007, 2009), Iranzo and Peri (2009), di Giovanni, Levchenko and Ortega (2015), Docquier, Ozden and Peri (2014), Ehrlich and Kim (2015), Caliendo et al. (2017), and Battisti et al. (2018).[7] Many of these papers study the global

[6] These opposing effects are consistent with contrasting impacts of immigration on imports documented by empirical literature, as discussed in Section 2.

[7] Caliendo et al. (2017) document the importance of trade, migration, and their interaction channels in quantifying the welfare impacts of immigration policies. They, however, focus on goods trade in the EU and ignore offshoring channels.

welfare gains from immigration. The existing literature has identified several important channels for instance, cross-country productivity differences, access to product varieties, housing prices, the role of imperfect substitutabilities, among others. Piyapromdee (2021) studies welfare impacts of immigration across U.S. cities using a spacial-equilibrium model and shows that these welfare effects depend on worker's responses to immigration. Our paper complements the above literature by highlighting the role of firms' adjustment in offshoring activities that is one important but often overlooked channel that affects the welfare impacts of immigration.

The empirical literature has documented a strong impact of immigration on offshoring.[8] Olney (2013) finds that an increase in immigration reduces both the extensive and intensive margins of offshoring. Ottaviano, Peri and Wright (2013) also give evidence of substitutability between immigrant and offshore workers. Olney and Pozzoli (2019) study the relationship between immigration and offshoring by exploring whether an influx of foreign workers reduces the need for firms to locate production activities abroad. Their paper also shows that an exogenous increase in immigration reduces firm-level offshoring at both the intensive and extensive margins. There is also literature that finds a positive relationship between immigration and FDI, for instance, Buch, Kleinert and Toubal (2006), Javorcik, Çağlar Özden, Spatareanu and Neagu (2011), and De Simone and Manchin (2012).[9] However, much of this literature focuses on offshoring in the manufacturing sector and on low-skilled immigration.

The recent empirical literature has focused on skilled immigration and documented substitutability between skilled immigration and offshoring in the skilled services sector. Ottaviano, Peri and Wright (2018) explore the impact of immigrants on the imports, exports, and productivity of service-producing firms in the U.K. They highlight that immigrants may substitute for imported intermediate inputs (offshore production) and lead to a re-assignment of tasks among offshore and immigrant workers. They find that a 10 percent increase in the bilateral immigrant share reduces intermediate services imports by approximately 1-2 percent, therefore suggesting a negative correlation between immigrant and offshore workers in the services sector (primarily concentrated in the professional, scientific, and technical activities) in the U.K.

Glennon (2020) is another recent paper that empirically analyzes the impact of H-1B visa restrictions on increased foreign affiliate activity using matched firm-level data. She finds that such restrictions caused an increased foreign affiliate activity at both the intensive and extensive margin. The result that 0.3 jobs were offshored for every unfilled H1-B position is consistent with our calibrated model — a decline in the immigration cap leads to higher offshore labor hiring, but this increase is less than the immigration cap's decline. Therefore, Glennon's paper can be used to validate the paper's results on the extent of offshoring while the current paper goes beyond to measure general equilibrium effects on welfare and wages.

Our paper is also related to the extensive literature that studies the impact of immigration on trade. The empirical literature has documented that immigrants may demand goods and services

[8]See Hummels, Munch and Xiang (2018) for the literature review on the impacts of offshoring on labor markets.

[9]Kugler and Rapoport (2007) and Tomohara (2017) document contemporaneous substitutability and dynamic/long-run complementarity between migration and FDI.

from their home countries, leading to an increase in imports (Gould 1994 and Head and Ries 1998). On the other hand, as mentioned above, the literature has also documented that immigrants and imported intermediate inputs may be substitutes when a good is part of a production chain. Our framework is consistent with both these effects — an increase in skilled immigrants would tend to increase intermediate imports (from non-affiliated firms in our framework) but would decrease intermediate imports from affiliated firms (due to substitutability between immigrant and offshore labor).

To the best of our knowledge, our paper is the first to incorporate skilled immigration, offhsore labor hiring, and intermediate input trade in a two-country general equilibrium framework with immigration policy frictions that mimic the U.S. and endogenous firm responses to policy changes. This allows us to find the welfare impacts of immigration policy changes in the U.S. and explicitly account for the role of offshoring in influencing these welfare impacts. We also gain some novel insights on the impact of immigration on intermediate input trade (from affiliated and non-affiliated firms) and the role of offshoring in influencing this. This would not be possible in models that separately study the impact of skilled immigration on imported intermediate trade or on offshoring at foreign affiliates within a partial equilibrium framework.

This research also adds to the emerging literature that examines the implications of high skilled migration. This includes Borjas and Doran (2012), Doran, Gelber and Isen (2014), Peri, Shih and Sparber (2015b,a), Kerr, Kerr and Lincoln (2015), Mayda et al. (2018), and Hanson, Kerr and Turner (2018). Most of these papers study the empirical impacts of the H1-B policy changes. In addition, our paper is related to the literature that studies unskilled immigration and offshoring in a dynamic general equilibrium model (Mandelman and Zlate 2020).

3 The Growth of The Professional, Scientific, and Technical Services Sector

In this section, we motivate our focus on the skilled services sector – the Professional, Scientific, and Technical Services sector (North American Industry Classification System, NAICS 54). In doing so, we highlight some trends within this sector that also motivate our modeling framework.

Since our focus is on skilled immigration policy, we want to focus on the most relevant sectors for hiring skilled immigrant workers. Since its inception in 1990, the H1-B visa program has been the dominant entry route for foreign skilled workers into the U.S. labor force. Within the H1-B program, the bulk of firm demand for skilled immigrant workers is accounted for by the Professional, Scientific, and Technical Services sector.[10] Before filing an H1-B petition, firms need to submit a Labor Condition Application (LCA) with the Department of Labor in which they specify the number of foreign workers they would like to hire for a particular occupation. Over 2014-18, around 75% of LCAs were filed within the Professional, Scientific, and Technical Services

[10]This includes activities such as accounting and bookkeeping, information and data processing, computer programming, and management and consulting services.

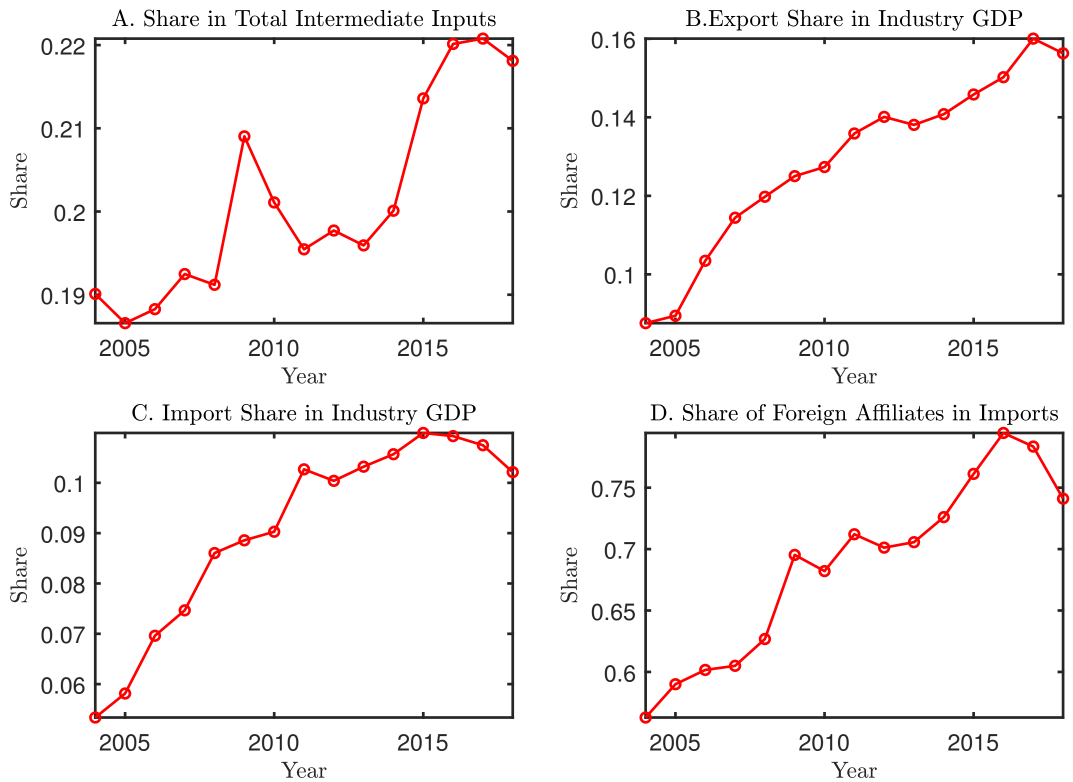

Figure 1: Rising Importance of Skilled Service Sector in the U.S.

Notes: Authors' calculations from Bureau of Economic Analysis (BEA) Input-Output Tables for NAICS sector 54 (professional, scientific, and technical services sector). Data by affiliation computed from the BEA services trade data for ICT and business service sectors.

sector (Figure A.1).[11]

Since the bulk of the newly hired skilled immigrant workers are employed by firms in the skilled services sector, our study is motivated by firm offshoring in this sector.

Moreover, our framework focuses on skilled immigrant labor employment at domestic firms that have foreign affiliates. This is consistent with the evidence in Yeaple (2017) that multinational firms are more likely as a whole to obtain H-1B visas compared to non-multinationals, even after controlling for firm characteristics that are associated with demand for skilled labor.

Next, we want to analyze trends related to the use of output in the skilled services sector as an intermediate good, domestically, and in trade, since these are crucial elements of our model. Figure 1 shows that this sector currently accounts for about 22% of the total intermediate inputs used in the U.S. economy, and there has been an increasing trend over time (Bureau of Economic

[11] Yeaple (2017) also mentions that many of the intensive users of the temporary visa programs are in service industries, such as computer design, publishing, management consulting. Ottaviano, Peri and Wright (2018) also note that even in the U.K., both immigrants and services trade is relatively concentrated in the same sectors — professional, scientific, and technical activities.

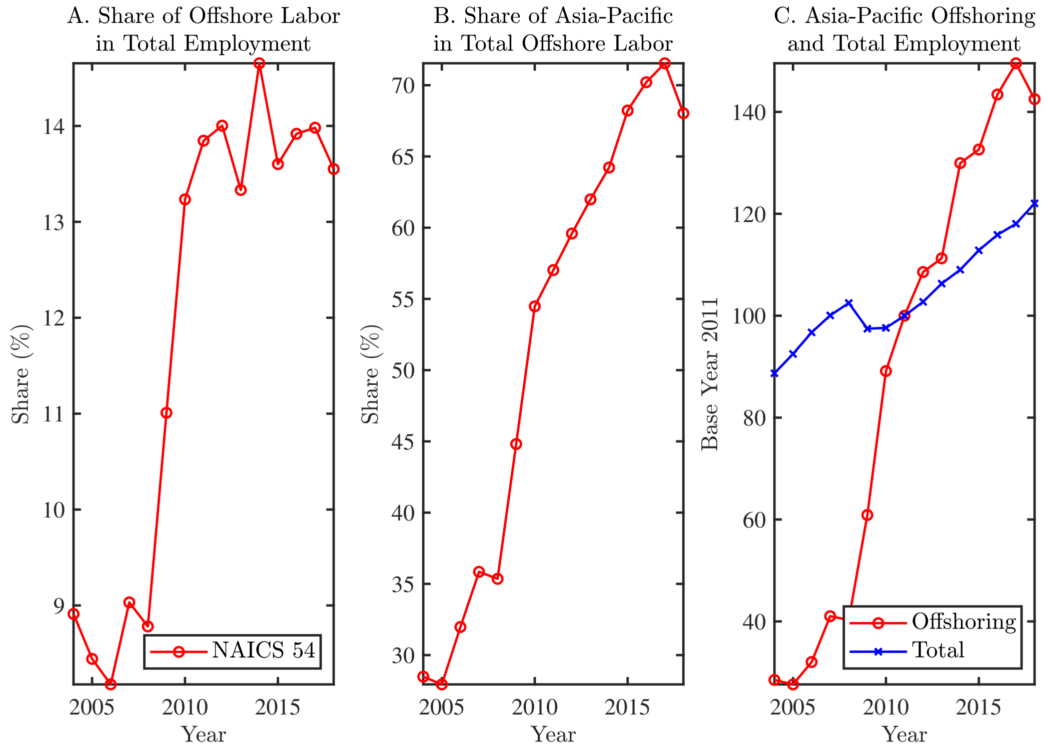

Figure 2: Employment at Foreign Affiliates

Notes: Authors' calculations from BEA services trade data. Number of employees are in thousands for the first panel, and the annual growth rates and share of Asia-Pacific are in percentages in the second and third panels, respectively.

Analysis, BEA Input-Output Use tables). Moreover, between 2004 and 2018, the export share in total industry GDP increased from 9% to 16% and the corresponding import share rose from 5% to 11%. Our framework has two channels of imports – import of output produced offshore at an affiliate and import from non-affiliated firms. Figure 1 also shows that the share of foreign affiliates in total imports within this sector has grown significantly and is currently over 70%.

Most importantly, this sector has witnessed significant growth in offshore labor employment in recent years. In Figure 2, Panel A reports the share of employment in U.S. majority-owned foreign affiliates as a proportion of total employment within this sector. This share has witnessed a substantial increase from 9% to around 15%. Panel B shows that this increase was concentrated in specific countries like India and China — the share of Asia-Pacific in U.S. majority-owned foreign affiliate employment increased from 30% in 2004 to over 70% in 2018.[12] Yeaple (2017) documents that India is a considerable outlier for skilled foreign workers in the U.S. via the temporary visa programs.

Overall, these trends indicate the growing importance of this sector as an intermediate good

[12]Within Asia Pacific, India accounted for 65% of the employment in majority-owned Foreign affiliates (BEA Direct Investment and Multinational enterprise data).

and in trade. Particularly noticeable is the increase in offshoring within this sector with respect to employment in foreign affiliates of U.S. firms, particularly in Asia Pacific countries.

4 Baseline Model

The baseline model features a two-country (Home and Foreign), two-sector (final and intermediate goods) economy populated by skilled and unskilled households. We denote foreign variables with an asterisk *. Monopolistically competitive firms produce imperfectly substitutable varieties of final consumption goods at Home and Foreign. The production technology of final good producers in each country combines a basket of domestic and imported varieties of intermediate inputs with domestically available unskilled labor.

Monopolistically competitive intermediate producers at Home produce output using domestic, immigrant, and offshore skilled labor. In order to hire immigrant labor, Home intermediate firms have to pay a cost for each additional worker and are subject to an immigration policy-imposed cap. To hire offshore skilled labor in Foreign, these firms have to pay a fixed cost to maintain their relationship with a Foreign affiliate and an iceberg trade cost to bring the output produced offshore back to Home.

The policy-imposed immigration cap determines the supply of skilled immigrants. Firms' optimal demand for immigrant labor ensures that expected cost of hiring an additional immigrant is equal to the expected discounted benefit of hiring that worker. The cap and firm demand endogenously determine the probability of hiring immigrant workers, which then affects the expected cost of hiring immigrant workers. Firms in our model hire labor offshore till the marginal costs of domestic and offshore production are equalized. Changes in policies and/or trade costs influence how much output that is produced by each set of workers. In this paper, we do not focus on the choice to start a foreign affiliate. We focus on the expansion of already existing affiliates in response to changes in immigration policy.

Our model differs from an offshoring model with trade in tasks in the previous literature such as Grossman and Rossi-Hansberg (2008). In their model, firms divide output into tasks and there is a cutoff for the set of tasks performed by domestic and offshore workers and this cutoff is endogenously determined by the equalization of the cost of the marginal task. In contrast, we assume that different types of workers produce the same output in firms and firms optimally choose how much is produced domestically vs offshore.[13] Our model can be interpreted as firms in the final consumption good sector producing a single final output using un-skilled labor input and a skill-intensive intermediate input bundle that is an aggregation of output produced by tasks performed by domestic, immigrant, and offshore skilled workers, and also imported intermediate inputs.

We assume that the Home country is more productive than the foreign, which generates vertical offshoring and immigration in only one direction. Therefore, Foreign intermediate producers produce output using only native skilled labor, and there is no migration from Home to Foreign.

[13] For instance, computer programming can be completed by any set of workers even though the workers can potentially differ in their relative productivity.

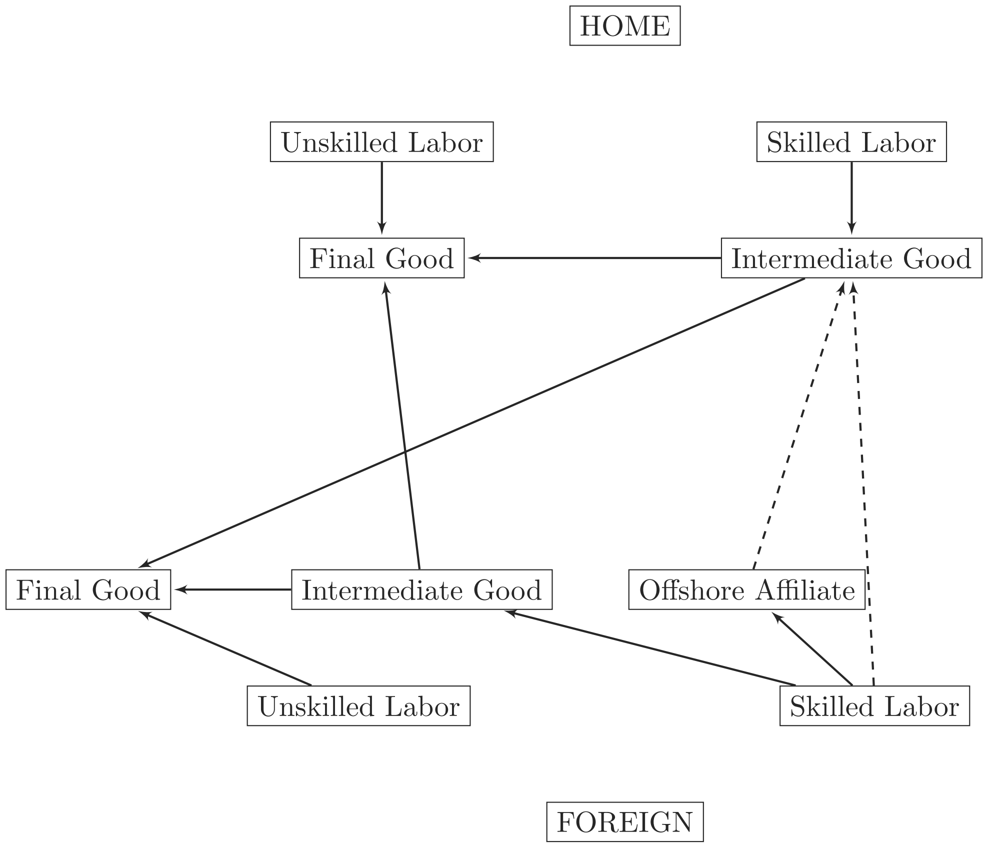

Figure 3: Model Setup

Figure 3 summarizes the production setup at Home and Foreign.

4.1 Households

The Home economy consists of a continuum of three types of infinitely-lived domestic households that supply units of skilled (domestic/native and immigrant) and unskilled labor inelastically. The representative native household's labor supply is normalized to be 1, and that of the representative unskilled household is $\bar{l}_u$. Each skilled and unskilled representative household has the same preferences over a basket of goods produced at Home. The lifetime utility of skilled domestic and immigrant (denoted by d and f, respectively), and unskilled households (denoted by u) is given by:

$$\max_{C_{j,t}} \mathbb{E}_t \sum_{k=t}^{\infty} \beta^{k-t} \ln C_{j,k}, \qquad \forall j \in \{d, f, u\}, \tag{1}$$

where $\beta \in (0,1)$ is the subjective discount factor, and $C_{j,t} = \{\int_{v\in\Upsilon}[c_{j,t}(v)]^{\frac{\theta-1}{\theta}}dv\}^{\frac{\theta}{\theta-1}}$ is the consumption basket of each household. Here, $\theta > 1$ is the household's symmetric elasticity of substitution across varieties (v) of the final consumption good. The associated consumption-based price index for the final good in units of Home consumption is $1 = \{\int_{v\in\Upsilon}[\rho_t(v)]^{1-\theta}dv\}^{\frac{1}{1-\theta}}$, where $\rho_t(v)$ is the price of variety v in units of consumption. The demand for variety v by household j is given by $c_{j,t}(\upsilon) = [\rho_t(\upsilon)]^{-\theta} C_{j,t}$.

The budget constraint for the native skilled household is $w_{s,t} l_{d,t} + d_t = C_{d,t}$, where d_t is the total profit income from intermediate and final good producers at Home in units of Home consumption. The representative native household's labor supply $l_{d,t}$ is inelastic and normalized to be 1. In the baseline setup, skilled households are the firm owners.[14] The domestic real skilled wage $w_{s,t}$ is determined in the competitive labor market for skilled workers. Foreign and domestic skilled workers are paid the same wage in the baseline model. This is consistent with the overall evidence on native-born relative earnings as a percent of foreign-born for workers with a bachelor's degree or higher (Figure D1). Moreover, when filing a Labor Condition Application, firms attest that they will pay the worker the prevailing compensation for that occupation.

Immigrant skilled labor and domestic unskilled households consume the sum of their respective labor incomes. Therefore, we have $C_{f,t} = w_{s,t} l_{f,t}$, and $C_{u,t} = w_{u,t} \bar{l}_u$, where $w_{u,t}$ is the real wage paid to unskilled labor, and is also determined competitively in a separate unskilled labor market.

Households in Foreign face a similar maximization problem. The total inelastic supply of Foreign skilled households is given by $\bar{L}_s^*$. Non-emigrant Foreign skilled households are either employed in the Foreign intermediate goods sector or at offshore affiliates. The stock of Foreign skilled labor employed at offshore affiliates is $l_{o,t}$ and the Foreign labor employed by Home intermediate firms to cover the fixed cost of offshoring is $f_{o,t}$. The mass of Foreign intermediate firms is N_d^* and the total Foreign skilled labor employed at Foreign intermediate firms is $N_d^* l_{s,t}^*$.

There is perfect labor mobility across Foreign intermediate good producing firms and offshore affiliates and therefore, the skilled wage in Foreign, $w_{s,t}^*$, is the same for all skilled workers. The total firm profit in the Foreign economy is d_t^* and similar to Home, the firm owners in Foreign are domestic skilled households. All skilled workers in Foreign pool labor income and therefore the budget constraint of the representative skilled household in Foreign is given by:

$$C_{s,t}^* = w_{s,t}^* (l_{o,t} + f_{o,t} + N_d^* l_{s,t}^*) + d_t^*. \tag{2}$$

Unskilled Foreign workers consume their labor income, similar to those at Home. Their budget constraint is given by $C_{u,t}^* = w_{u,t}^* \bar{l}_u^*$, where $\bar{l}_u^*$ is the inelastic stock of unskilled workers in Foreign and $w_{u,t}^*$ is the unskilled wage determined in a competitive labor market in Foreign.

4.2 Final Good Producers

The Home consumption basket is comprised of imperfectly substitutable varieties $\upsilon \in \Upsilon$ produced by a constant mass (normalized to 1) of monopolistically competitive Home final good producers. The final good firms produce output using unskilled labor, $l_{u,t}$, and the basket of intermediate goods m_t. The technology is represented by the Cobb-Douglas production function:

$$y_t(\upsilon) = Z_t \left[m_t(\upsilon)\right]^{\alpha} \left[l_{u,t}(\upsilon)\right]^{1-\alpha}, \tag{3}$$

[14] In the quantitative exercises, we allow for alternate profit distribution across households.

where Z_t denotes the aggregate total factor productivity at Home, which is exogenous and follows an AR(1) process.[15] The basket of domestic (y_1) and imported (y_x^*) intermediate inputs is given by:

$$m_t = \left[\int_0^1 (y_{1,t}(\omega)^{\frac{\phi-1}{\phi}} d\omega) + \int_0^{N_d^*} (y_{x,t}^*(\omega)^{\frac{\phi-1}{\phi}} d\omega) \right]^{\frac{\phi}{\phi-1}}. \tag{4}$$

The elasticity of substitution across different intermediate varieties (ω) is $\phi > 1$ and N_d^* is the mass of foreign intermediate good firms.

In minimizing costs, each firm chooses its optimal demand of the intermediate composite and unskilled labor as $m_t = \alpha[\theta/(\theta-1)]Y_t^c/\rho_{m,t}$ and $l_{u,t} = (1-\alpha)[\theta/(\theta-1)]Y_t^c/w_{u,t}$, respectively, where Y_t^c is the Home aggregate demand (defined in Section 4.4). $\rho_{m,t}$ is the price index of the domestic and foreign intermediate input composite used in the production of the Home final good.

The optimal demand for Home intermediate input variety ω is given by $y_{1,t}(\omega) = [\rho_{1,t}(\omega)/\rho_{m,t}]^{-\phi} m_t$ and that of the Foreign intermediate input variety ω is $y_{x,t}^*(\omega) = [\rho_{x,t}^*(\omega)/\rho_{m,t}]^{-\phi} m_t$, where $\rho_{1,t}(\omega)$ and $\rho_{x,t}^*(\omega)$ are the equilibrium prices of domestic and imported varieties (described in Section 4.3). Imports are subject to an iceberg trade cost τ.

Each final good producing firm sets its price as $\rho_t(\upsilon) = [\theta/(\theta-1)][\rho_{m,t}/\alpha]^{\alpha}[w_{u,t}/1-\alpha]^{1-\alpha}/Z_t$. Each firm's per period profit is given by $d_{c,t} = \rho_t y_t - \rho_{1,t} y_{1,t} - N_d^* \rho_{x,t}^* y_{x,t}^* - w_{u,t} l_{u,t}$. Since consumption goods are not traded, the final good producers serve the domestic market only. Therefore, the market clearing for each firm implies that $y_t(\upsilon) = [\rho_t(\upsilon)]^{-\theta} Y_t^c$.

A constant mass, normalized to 1, of consumption good producers in Foreign face an identical problem. The corresponding equilibrium conditions are denoted with a '*'.

4.3 Intermediate Good Producers

There is a continuum of monopolistically competitive firms, each producing a differentiated variety $\omega \in \Omega$.[16] There is no endogenous entry or exit, and we normalize the constant mass of firms to 1. Output $y_{m,t}(\omega)$ produced by each intermediate firm is subject to the following production technology.

$$y_{m,t}(\omega) = Z_t \left[l_{d,t}(\omega) + a l_{f,t}(\omega)\right] + Z_t^* \frac{l_{o,t}(\omega)}{\tau_o} \tag{5}$$

Output at firm ω can be produced using three types of labor — domestic skilled ($l_{d,t}(\omega)$), skilled immigrant ($l_{f,t}(\omega)$), and skilled offshore ($l_{o,t}(\omega)$). A part of the intermediate good can be produced using labor hired offshore, and the productivity of offshore labor is subject to the total factor productivity in Foreign, Z_t^*. However, an iceberg cost (τ_o) is associated with importing back output produced offshore.

The presence of offshore affiliates expands the availability of skilled labor for domestic firms as they can produce part of the intermediate good in Foreign using Foreign labor. In the benchmark

[15] Note that we do not present any results with aggregate uncertainty in this paper.

[16] Monopolistic competition is essential to the framework since firms need to pay costs for hiring foreign skilled workers.

model, domestic, immigrant, and offshore workers are perfect substitutes in production but differ by their relative productivity. The productivity of immigrant workers relative to domestic workers is denoted by a.[17]

As described below, firms need to pay a cost for each immigrant skilled worker. Why would firms be willing to pay this cost instead of hiring more domestic skilled workers? One explanation could be that firms try to hire H1B workers because they cannot find enough domestic skilled workers to fill their open positions.[18] This is consistent with our model setup which features inelastic supply of domestic skilled labor. However, given a competitive labor market, additional costs of hiring foreign workers, and flexible real skilled wages, the model equilibrium would feature a zero firm demand for immigrant skilled workers in the absence of additional benefits of hiring foreign workers. It is possible that firms pay a lower wage to immigrant workers. However, by law firms are required to pay native and immigrant skilled workers similar wages. Moreover the relative wage of native vs foreign-born skilled workers in the U.S. has on average been one during relevant time horizon (see Figure D1). Therefore, we assume that domestic and immigrant skill workers are paid the same wage but we allow the relative productivity of immigrant and native workers to differ. This creates a wedge between wages paid to immigrant workers and the marginal revenue product from an additional foreign worker hired and leads to positive hiring of foreign workers every period. We do not impose that $a > 1$. However, this turns out to be an outcome of the calibration.

Immigration Policy We model immigration policy to mimic U.S. skilled immigration policy. Domestic firms face certain immigration policy restrictions when hiring immigrant workers: Firms have to pay hiring costs, and there is a policy-imposed cap on the number of Foreign workers that can be hired each period.[19] The sunk hiring costs $f_{R,t}$ (in units of Home consumption) must be paid for each Foreign skilled worker that the firm applies for. If each firm chooses to submit applications for $N_{e,t}(\omega)$ workers, then the total cost that the firm incurs for hiring immigrants is $f_{R,t}N_{e,t}(\omega)$. Higher immigration policy costs imply a more restrictive immigration policy.

The entry cap for Foreign skilled workers is exogenously set at $\bar{N}_{e,t}$. Each firm submits applications for $N_{e,t}(\omega)$ Foreign skilled workers and the probability or fraction of each application being selected is given by

$$\mu_t = \frac{\bar{N}_{e,t}}{\int_{\omega \in \Omega} N_{e,t}(\omega) d\omega} \tag{6}$$

[17] While there is empirical evidence for imperfect substitutability between natives and immigrants within the same education and experience group (Ottaviano and Peri 2012), some debates are surrounding this, especially among those who advocate a stricter immigration policy. Therefore, we do not include complementarities in the benchmark case so that our welfare results can be interpreted as the 'worst case' impacts of immigration policy changes.

[18] Some firms have claimed this publicly (see, e.g. https://www.wsj.com/articles/annual-race-for-tech-visas-is-under-way-1459503001).

[19] Firms in multiple surveys (for instance, by the GAO (2011) report), document a range of direct and indirect costs associated with the H-1B program, including legal and administrative costs. Firms note that apart from the filing fees paid to the Department of Homeland Security, the main cost incurred is due to the opportunity cost of the time and effort spent in the process, which is captured by the regulatory component of the sunk cost, $f_{R,t}$, in the model.

Therefore, if each firm submits $N_{e,t}(\omega)$ applications, it will get $\mu_t N_{e,t}(\omega)$ workers. Since the cap has been binding since 2004, we only consider cases where $\mu_t < 1$, i.e., the aggregate demand for skilled foreign workers across all firms ($[\int_{\omega\in\Omega} N_{e,t}(\omega)d\omega]$) is greater than the cap ($\bar{N}_{e,t}$), and the cap binds. Firms are of measure 0 and take μ_t as given in their hiring decision. A lower cap also represents a more restrictive immigration policy as it lowers the fraction of accepted applications.

A fraction δ of immigrant skilled workers currently employed by domestic firms (including newly hired workers from the previous period) are separated from firms at the beginning of the period. Foreign workers that end up separating return to their origin country and get added back to the skilled labor supply in Foreign.[20] Then, the stock of period $t+1$ immigrant skilled workers, $l_{f,t+1}(\omega)$, depends on the stock of period-t workers that remain in the Home country, i.e., $(1-\delta)l_{f,t}(\omega)$, and the fraction of newly hired foreign skilled workers in period-t that do not separate, i.e., $(1-\delta)\mu_t N_{e,t}(\omega)$.

Therefore, there is a time to build lag, and the stock of immigrant skilled labor at firm producing variety ω evolves according to the following law of motion:

$$l_{f,t+1}(\omega) = (1-\delta)\left[l_{f,t}(\omega) + \mu_t N_{e,t}(\omega)\right]. \tag{7}$$

The period-t hiring probability, μ_t, depends on period-t aggregate demand for foreign skilled labor and the period-t immigration cap. Period-t demand for foreign skilled labor at each firm is determined optimally, given the law of motion in Equation (7) and the expectation of period $t+1$ output, which depends on the current aggregate productivity Z_t, and expectation of future productivity shock ϵ_{t+1}. The current productivity does not directly impact the firm's hiring decision of foreign skilled workers today. Instead, persistence in the productivity process causes it to affect the firm's expectation of future productivity and hence its current decision. Therefore, firms take into account both the current and future states in their optimal determination of $N_{e,t}(z)$.

Offshore Labor Hiring Each period, firms can also hire Foreign skilled labor at an offshore affiliate. To do this, the firm must pay a per-period fixed cost, $f_{o,t}$, in units of Foreign skilled labor.[21] Firms pay the fixed offshoring cost and choose offshore labor $l_{o,t}$, taking the Foreign skilled wages $w^*_{s,t}$ as given.[22] Therefore, if period-t offshore labor hired is $l_{o,t}$, then the total cost incurred by the firm is $Q_t w^*_{s,t} l_{o,t}(\omega) + Q_t f_{o,t} w^*_{s,t}/Z^*_t$. Here Q_t is the real exchange rate defined as the units of the Home consumption basket needed to purchase one unit of the Foreign consumption basket. There is no time to build lag for offshore labor hired — foreign workers hired in period t become productive immediately in the offshore affiliate.

Optimal Hiring of Skilled Foreign Workers Output produced by each intermediate good firm is sold to the domestic final goods sector ($y_{1,t}$ at a price $\rho_{1,t}$) and to the Foreign final goods

[20]For immigrants, there is an exogenous probability of return to the country of origin to account for the fact that a bulk of foreign skilled workers are on a temporary work visa and a fraction returns every period.

[21]This can be interpreted as labor or managers hired to maintain operations in the offshore affiliates.

[22]In the model, all firms are symmetric, and therefore all firms end up offshoring. We calibrate the model such that firm profits are always positive after paying the fixed offshoring cost.

sector ($y_{x,t}$ at a price $\rho_{x,t}$). However exports (and imports) are subject to an iceberg trade cost τ. The presence of the iceberg trade cost $\tau > 1$ implies that in order to export $y_{x,t}(\omega)$ units of output, the firm needs to produce $\tau y_{x,t}(\omega)$. Therefore, output produced must satisfy the following market clearing.

$$y_{m,t} = y_{1,t} + \tau y_{x,t} \tag{8}$$

Expressed in units of the consumption basket, the inter-temporal profit function of a firm producing variety ω is given by:

$$\mathbb{E}_t \sum_{k=t}^{\infty} \beta_{k,t} \Big\{ \rho_{1,k}(\omega) y_{1,k}(\omega) + Q_k \rho_{x,k}(\omega) y_{x,k}(\omega) \\ - f_{R,k} N_{e,k}(\omega) - w_{s,k} \left[l_{f,k}(\omega) + l_{d,k}(\omega) \right] - Q_k w^*_{s,k} \left[l_{o,k}(\omega) + f_{o,k}/Z^*_k \right] \Big\},$$

where the inter-temporal discount factor that the firm applies to its profits is $\beta_{k,t} \equiv \beta u'(C_{s,k})/u'(C_{s,t})$ since domestic skilled households are assumed to be the firm owners in the baseline model. The revenue of the intermediate good firms include total value of sales to the domestic final good firms ($\rho_{1,t}(\omega) y_{1,t}(\omega)$) and total sales to the foreign final good firms $Q_t \rho_{x,t}(\omega) y_{x,t}(\omega)$. The costs include costs incurred due to immigration policy, wages paid to domestic and immigrant workers employed in the Home country, wages paid to foreign offshore workers employed in Foreign, and fixed offshoring costs.

Each period, Home intermediate firms optimally choose $\rho_{1,t}(\omega)$, $y_{1,t}(\omega)$, $\rho_{x,t}(\omega)$, $y_{x,t}(\omega)$, $N_{e,t}(\omega)$, $l_{f,t+1}(\omega)$, $l_{o,t}(\omega)$, and $l_{d,t}(\omega)$, by maximizing expected discounted profits subject to the following constraints:

1. $Z_t[l_{d,t}(\omega) + a l_{f,t}(\omega)] + Z^*_t l_{o,t}(\omega)/\tau_o = y_{1,t}(\omega) + \tau y_{x,t}(\omega)$
2. $y_{1,t}(\omega) = \left[\frac{\rho_{1,t}(\omega)}{\rho_{m,t}}\right]^{-\phi} m_t$
3. $y_{x,t}(\omega) = \left[\frac{\rho_{x,t}(\omega)}{\rho^*_{m,t}}\right]^{-\phi} m^*_t$
4. $l_{f,t+1}(\omega) = (1-\delta)\left[l_{f,t}(\omega) + \mu_t N_{e,t}(\omega)\right]$.

The first constraint spells out the market clearing condition after imposing the production technology. The second and third constraints specify the equilibrium demand for domestic and export sales by domestic and Foreign final good firms, respectively. Firms take wages and immigration policy as given.

The optimal conditions are derived in Appendix B. As long as fixed offshoring costs ensure positive profits, firms hire offshore labor till the marginal cost of hiring labor offshore is equalized with that of hiring domestically available skilled labor as follows.

$$\tau_o Q_t \frac{w^*_{s,t}}{Z^*_t} = \frac{w_{s,t}}{Z_t} \tag{9}$$

Additionally, each period, firms hire and submit applications for skilled immigrant workers such that the expected discounted benefit generated from an additional skilled immigrant worker is equal to the expected cost of hiring immigrant workers:

$$\frac{f_R}{\mu_t} = (1-\delta)\mathbb{E}_t\left[\beta_{t,t+1}\left(aZ_{t+1}\psi_{t+1} - w_{s,t+1} + \frac{f_R}{\mu_{t+1}}\right)\right] \tag{10}$$

where ψ_t is the marginal cost of production or the Lagrange multiplier on constraint 1. The expected cost of hiring immigrant workers is f_R/μ_t. Since firms have to pay f_R for each immigrant worker that they apply for, and μ_t is the probability of the application being selected, firms effectively pay f_R/μ_t to hire each immigrant worker. The right hand side of Equation (10) gives the expected benefit of hiring immigrant workers — the marginal revenue product of each immigrant worker ($aZ_{t+1}\psi_{t+1}$) net of skilled wage paid ($w_{s,t+1}$) at time $t+1$, since there is a one-period time to build. Essentially, hiring immigrant labor is like an investment decision for firms, and the stock of immigrant workers is governed by Euler equation

Immigrant and domestic skilled workers are paid the same wage every period and this skilled wage is equal to the marginal revenue product of skilled domestic workers, i.e., $w_{s,t} = \psi_t Z_t$. We can substitute this wage and Equation (9) in Equation (10) to express the first-order condition as follows.

$$\frac{f_R}{\mu_t} = (1-\delta)\mathbb{E}_t\left[\beta_{t,t+1}\left(aw_{s,t+1} - w_{s,t+1} + \frac{f_R}{\mu_{t+1}}\right)\right] \tag{11}$$

Therefore relative productivity a creates a wedge between marginal revenue product and skilled wages paid to immigrant.[23]

Profit maximization implies that the price set by firm ω for the domestic final good producer is $\rho_{1,t}(\omega) = [\phi/(\phi-1)](w_{s,t}/Z_t)$ and the export price for the Foreign final good producer is $\rho_{x,t}(\omega) = Q_t^{-1}\tau\rho_{1,t}(\omega)$, where the export price is in units of Foreign consumption. Firm profits in period t are given by $d_{m,t}(\omega) = \rho_{1,t}(\omega)y_{1,t}(\omega) + Q_t\rho_{x,t}(\omega)y_{x,t}(\omega) - w_{s,t}l_{d,t}(\omega) - w_{s,t}l_{f,t}(\omega) - Q_t w^*_{s,t}l_{o,t}(\omega) - f_R N_{e,t}(\omega) - f_o Q_t w^*_{s,t}/Z^*_t$.

Foreign Intermediate Firms We normalize the constant mass of Foreign intermediate producers to N^*_d. Each Foreign intermediate firm ω produces output using their native skilled workers — the technology is given by $y^*_{m,t}(\omega) = Z^*_t l^*_{s,t}$. Foreign intermediate firms sell output locally and also export to the Home country final goods sector subject to the iceberg trade cost τ, i.e., $y^*_{m,t}(\omega) = y^*_{1,t}(\omega) + \tau y^*_{x,t}(\omega)$. Except for the hiring decision of immigrant and offshore workers, Foreign firms face a similar problem as Home firms and set prices for output sold domestically as $\rho^*_{1,t}(\omega) = [\phi/(\phi-1)](w^*_{s,t}/Z_t{}^*)$ and for output exported to Home as $\rho^*_{x,t}(\omega) = Q_t\tau\rho^*_{1,t}(\omega)$. Firm profits are given by $d^*_{m,t}(\omega) = \rho^*_{1,t}(\omega)y^*_{1,t}(\omega) + Q_t^{-1}\rho^*_{x,t}(\omega)y^*_{x,t}(\omega) - w^*_{s,t}l^*_{s,t}(\omega)$.

[23] Since firms face the same skilled wages and same immigration related costs, symmetric firms hire the same labor each period and have the same stock of labor each period. This simplifies the aggregation and we focus on the aggregate implications and relationships between immigration, offshoring, and trade, in this environment.

4.4 Aggregate Accounting and Equilibrium

Since firms in each sector are identical, the aggregation over varieties is straightforward. Aggregate intermediate sector output is given by $y_{m,t} = Z_t(l_{d,t} + al_{f,t}) + Z_t^* l_{o,t}/\tau_o$ and the associated price index is $(\rho_{m,t})^{1-\phi} = (\rho_{1,t})^{1-\phi} + N_d^*(\rho_{x,t}^*)^{1-\phi}$. Aggregate consumption by households at Home is the sum of consumption by skilled and unskilled domestic and immigrant workers, i.e., $C_{s,t}+C_{u,t}+C_{f,t}$. Home labor market clearing requires $l_{d,t} = 1$ and $l_{u,t} = \bar{l}_u$. The aggregate demand at Home is given by $Y_t^c = w_{s,t}(1 + l_{f,t}) + w_{u,t}\bar{l}_u + d_t + f_R N_{e,t}$, where the budget constraints have been substituted.[24] Aggregate Home profits are given by the sum of intermediate good and final goods sector profits, i.e., $d_t = d_{1,t} + d_{c,t}$.

Similarly in Foreign, aggregate intermediate output is $N_d^* y_{m,t}^* = N_d^* Z_t^* l_{s,t}^*$ and the associated price index is $(\rho_{m,t}^*)^{1-\phi} = (\rho_{x,t})^{1-\phi} + N_d^*(\rho_{1,t}^*)^{1-\phi}$. Aggregate consumption by households in Foreign is $C_{s,t}^* + C_{u,t}^*$. Foreign labor market clearing requires that the sum of foreign labor employed in offshore affiliates (including labor that covers the fixed cost), foreign non-affiliated firms, and immigrant workers employed in the domestic economy, should be equal to the aggregate inelastic supply of skilled foreign labor ($\bar{L}_s^*$), i.e., $\bar{L}_s^* = l_{o,t} + f_{o,t} + l_{f,t} + N_d^* l_{s,t}^*$, and for unskilled foreign labor: $l_{u,t}^* = \bar{l}_u^*$ Therefore, immigrant workers employed at Home are part of the skilled labor supply in Foreign and any changes in Home immigration policy affects the skilled labor supply in Foreign. Aggregate accounting in Foreign requires that the aggregate demand is given by $Y_t^{c*} = w_{s,t}^*(l_{o,t} + f_{o,t} + N_d^* l_{s,t}^*) + w_{u,t}^* \bar{l}_u^* + d_{c,t}^* + N_d^* d_{1,t}^*$.

Finally, any trade imbalance must be offset by payments incurred for offshore production as follows.[25]

$$Q_t \rho_{x,t} y_{x,t} - N_d^* \rho_{x,t}^* y_{x,t}^* = Q_t w_{s,t}^* l_{o,t} + Q_t f_o w_{s,t}^* / Z_t^* \tag{12}$$

Table C2 summarizes the main equations in the model.

5 Analytical Solution and Intuition

This section outlines some analytical results highlighting the intuition behind the relationship between skilled immigration, offshoring, and intermediate imports. See Appendix C.1 for the details and derivations.

[24] The R.H.S is the aggregate consumption by domestic households plus the sunk cost of hiring immigrant workers, which is in units of Home consumption.

[25] Substituting the expression for profits in the aggregate demand equation also gives this condition.

The level of offshoring $l_{o,t}$ in the baseline model is given by

$$\boldsymbol{l_{o,t}} = \left(\frac{1}{\tau_o} + \Lambda - \frac{\Xi\tau^{2\phi-1}}{\phi} + \frac{\tau}{\phi}\right)^{-1} \Bigg\langle \left(\Lambda - \Xi\tau^{2\phi-1} + \Xi\tau\right) \boldsymbol{\bar{L}_s^*} - \left(\Lambda - \Xi\tau^{2\phi-1} + \Xi\tau + \frac{Z_t}{Z_t^*}a\right) \boldsymbol{l_{f,t}} - \left\{\Lambda + \Xi\tau\frac{\phi(Z_t^*-1)+1}{\phi}\left[1-\tau^{2(\phi-1)}\right]\right\} \boldsymbol{f_o} - \frac{Z_t}{Z_t^*}\Bigg\rangle, \tag{13}$$

where $\Lambda = \tau^{\phi-1}/(N_d^*\tau_o^\phi)$ and $\Xi = \{\tau\tau_o[1+N_d^*(\tau\tau_o)^{\phi-1}]\}^{-1}$. In Appendix C.1, we show that $\Lambda - \Xi\tau^{2\phi-1} > 0$. Therefore all the coefficients in the expression for $l_{o,t}$ are positive.

Equation (13) highlights the factors that affect offshore labor hiring by domestic firms. It shows that the offshore labor hired by the Home skilled intermediary ($l_{o,t}$) is increasing in the availability of skilled labor in Foreign ($\bar{L}_s^*$), decreasing in the stock of immigrant skilled labor at Home ($l_{f,t}$), decreasing in the fixed offshoring cost (f_o), and decreasing in the relative productivity at Home (Z_t/Z_t^*).

It is intuitive that a higher relative productivity at Home would mean that Home producers would prefer to produce more at Home relative to Foreign, and therefore the labor hired offshore would be lower. Moreover, any factor that increases the availability of skilled labor in Foreign (higher $\bar{L}_s^*$ or lower $l_{f,t}$), increases the level of offshore labor hired in the Foreign affiliate of the Home intermediate firm. This is also intuitive because a larger stock of skilled labor in Foreign will lower real wages and increase the incentive to produce offshore.

Equation (13) highlights the negative relationship between skilled immigrants and the level of offshore labor hired. When firms are able to hire less skilled immigrant workers at Home, they increase their offshore labor hiring and therefore increase the component of output produced in the Foreign economy. This would tend to increase imports by the domestic intermediate firm from the Foreign affiliate.

Next, we solve for the level of intermediate imports from Foreign non-affiliated firms as follows:

$$y_{x,t}^* = \frac{1}{1+N_d^*(\tau\tau_o)^{\phi-1}}\left\{\frac{Z_t^*}{N_d^*\tau}\bar{L}_s^* - \frac{Z_t^*}{N_d^*\tau}l_{f,t} - l_{o,t}\left[\frac{Z_t^*}{N_d^*\tau} + \frac{(\tau\tau_o)^{\phi-1}Z_t^*(\phi-1)}{\tau\phi}\right] - f_o\left[\frac{Z_t^*}{N_d^*\tau} + \frac{(\tau\tau_o)^{\phi-1}(\phi-1)}{\tau\phi}\right]\right\}. \tag{14}$$

From Equation (14) we can see another mechanism by which skilled immigrants affect domestic imports. To investigate the marginal effects, let us fix the level of offshoring at a constant value. For given fixed $l_{o,t}$, there is a negative relationship between the stock of skilled immigrant labor ($l_{f,t}$) and imported intermediate inputs from non-affiliated Foreign firms ($y_{x,t}^*$). However, once we account for the endogenous adjustment in offshoring following changes in skilled immigration, there is a net positive relationship between imported intermediate imports from non-affiliates and the stock of skilled immigrant labor.

The main implication of Equation (14) is that the qualitative impact of changes in skilled immigration on imports from non-affiliated firms depends on whether or not we account for firms' adjustment in offshore labor hiring. The increase in offshore labor hiring in affiliated firms following a decrease in skilled immigration leads to a relative reduction in output produced by non-affiliated firms, and therefore an increase in the relative price of imports from these firms, and a corresponding reduction in imported intermediate goods. Therefore, there is a positive relationship between skilled immigration and imports from non-affiliates (a reduction in skilled immigration results in a reduction of imports). However, when we do not account for the adjustment in offshoring following an immigration reduction, then the domestic intermediate sector output would fall relative to the foreign intermediate sector output, and therefore, the relative price of imports from non-affiliated firms would fall, resulting in an increase in imports from Foreign non-affiliated firms.

This is consistent with the responses to an immigration cap decrease, as discussed in Section 8. In the benchmark case in which we account for an adjustment in the level of offshoring, Home intermediate imports from non-affiliated firms fall after an immigration cap decrease (positive relationship). In contrast, in the alternate case in which we shut down the offshoring channel, imports increase (negative relationship).

In summary, a change in skilled foreign labor availability at Home leads to a firm adjustment in offshoring. The offshoring channel is not only crucial for the direct effects of immigration policy, but it is also important for the impact of immigration on imports for two reasons — 1) offshoring directly responds to immigration which affects imports from affiliated firms, and 2) offshoring indirectly impacts imports from non-affiliated firms. When firms adjust their offshore labor hiring in response to an immigration policy change, the impact of skilled immigration on total imports is ex-ante ambiguous. On the one hand, a decrease in skilled immigration increases offshoring and increases imports from offshore affiliates. On the other hand, imports from non-affiliated foreign firms fall.

6 Calibration

In order to study the dynamics numerically, we calibrate the parameters of the model under the assumption that the steady-state Home economy mimics the U.S. and Foreign mimics India during 2004 – 2017 period. The immigration policy cap was binding during this period. We interpret each period as a year to accommodate the annual allocation of the H-1B visa cap. We calibrate the parameters that pertain to immigration to match U.S. data from the Current Population Survey (CPS) and the United States Citizenship and Immigration Service (USCIS). Foreign labor supply parameters are calibrated to match education-wise labor available using data from the Indian Census. The steady-state aggregate productivity of the Home country Z is normalized to 1, and that off Foreign is set to 0.4 to match the average relative productivity data from the Penn World Tables.

The immigration cap $\bar{N}_e$ is set to 0.0022 in order to match the average cap imposed by actual

Table 1: A Priori Parameters

A Priori Parameters	Value	Target
Discount factor	$\beta = 0.96$	
Elasticity of substitution	$\phi = \theta = 3.8$	
Return migration	$\delta = 0.1$	Average return migration
Cap	$\bar{N}_e = 0.0022$	Cap/Domestic skilled labor
Domestic unskilled labor	$\bar{l}_u = 1.72$	Proportion of U.S. unskilled labor
Foreign skilled labor	$\bar{L}_s^* = 1.2$	India's skilled labor/U.S. skilled labor
Foreign unskilled labor	$\bar{l}_u^* = 4.58$	Proportion of Indian unskilled

Table 2: Targeted Moments

Target	Data	Model
Offshore labor/total employed	0.12	0.12
Ratio of exports to imports in skilled service sector	1.3	1.33
Average fraction of immigrant applications approved	0.4	0.4
Skill Premium	1.8	1.8
Ratio of regulatory costs to skilled wages	0.08	0.08

Table 3: Calibrated Parameters

Calibrated Parameters	Value
Skill Intensity	$\alpha = 0.5783$
Mass of Foreign Intermediate Firms	$N_d^* = 0.2078$
Sunk Immigration Cost	$f_R = 0.0333$
Immigrant Relative Productivity	$a = 1.0315$
Fixed offshoring cost	$f_o = 0.1065$

policy (85,000) as a proportion of the normalized average domestic skilled labor in the U.S. Domestic unskilled labor supply is calibrated to 1.72 (given the normalization of domestic skilled labor supply to 1) to match the share of domestic workers in the U.S. with less than a bachelor's degree of 34 percent. We rely on existing literature for some parameters. We set $\beta = 0.96$, which implies an annual real interest rate of 4 percent. Following Ghironi and Melitz (2005), we set the elasticities of substitution across product varieties equal to 3.8. The exogenous return shock to Foreign is set to $\delta = 0.1$, in order to match the annual return migration rate of 10% (North 2011).

We normalize iceberg trade cost τ to 1.2 and jointly calibrate $\{\alpha, N_d^*, f_R, a, f_o\}$ to minimize the squared residuals between model moments and targets in Table 2. Data on offshore labor, total labor employed domestically, and trade between affiliates and non-affiliates in the Professional, Scientific, and Technical Services sector is taken from the Bureau of Economic Analysis (BEA). Data on exports and imports in skilled service sector (Professional, Scientific, and Technical Services sector) is calculated from the Bureau of Economic Analysis Input-Output Use Tables for 2004-2017.

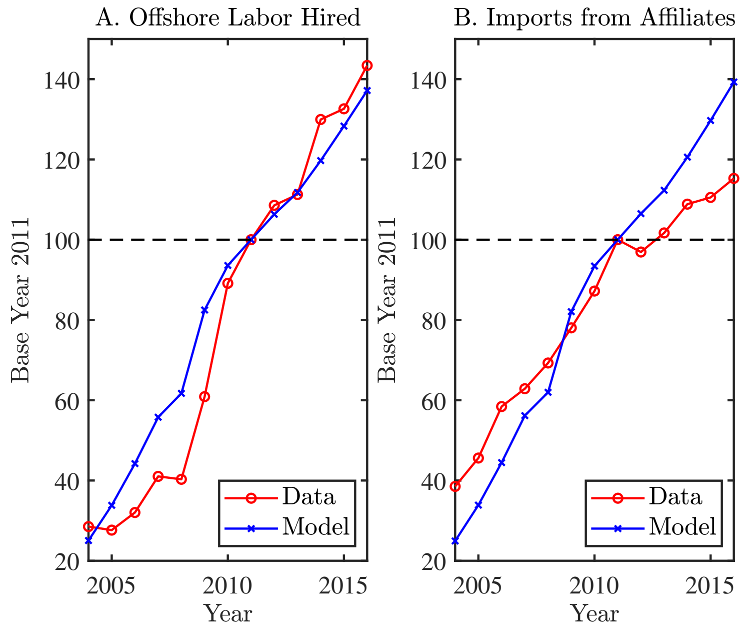

Figure 4: Offshoring: BEA Data vs Model

In the model, the ratio of exports to imports is given by $Q\rho_x y_x/[(Q\tau_o w_s^* l_o/Z^*) + (N_d^* \rho_x^* y_x^*)]$, i.e. the total exports to non-affiliated firms as a proportion of total imports, where $N_d^* \rho_x^* y_x^*$ is the total imports from non affiliated foreign firms and $Q\tau_o w_s^* l_o/Z^*$ is equivalent to the imports from offshore affiliated firms.

The resulting parameter values are highlighted in Table 3. In the baseline calibration, the iceberg offshoring cost is set equal to the iceberg trade cost.

7 Model vs Data Trends

Before we present the numerical results related to the welfare impacts, we want to confirm that the model generates trends that are consistent with the data. Therefore, in this section, we compare trends related to offshore labor hiring and imports from affiliated foreign firms in the skilled services sector in the data with our model predictions. To do this, we compute the productivity of the U.S. and India using real GDP data from 2004 to 2017 and re-calibrate Z_t and Z_t^* in each period to match the productivity growth. We keep the values of the other parameters constant when generating the model trends. The trends generated using the calibrated model are broadly consistent with the data as seen in Figure 4, where values were rebased to 100 for the year 2011. In Panel A, the level of offshore labor hiring corresponds to l_o in the model. The data trends measure the number of employees in U.S. offshore affiliates in the Professional, Scientific, and Technical Services sector (BEA data on Activities of U.S. Multinational Enterprises).

Panel B plots imports from affiliated firms in the model vs. data. The model variable is the value of the imported component of output from offshore affiliates ($Q_t \tau_o w_{s,t}^* l_{o,t}/Z_t^*$ or equivalently $w_{s,t} l_{o,t}/Z_t$). The measure in the data corresponds to real imports from affiliates, again computed from the BEA data on trade in services.

8 Transition Dynamics and Welfare Results in the Baseline Model

In this section, we solve the calibrated model numerically to compute the dynamics and welfare impacts of policy changes.[26]

In Section 8.1, we study the responses to a stricter immigration policy by considering an immigration cap reduction. In Section 8.2.1, we compute the welfare effects of a 10 percent cap reduction on domestic households and discuss how the results depend on the offshoring channel. In Section 8.2.2, we study the welfare impact of changes in trade and offshoring policies.

8.1 Dynamic Response to a Permanent Cap Reduction

Our main counterfactual exercise studies the impact of a stricter skilled immigration policy. To do that, we consider our model's responses to a permanent 10% cap reduction. The blue solid lines in Figure 5 give the dynamic responses in the baseline model in which we allow the level of offshoring to adjust. Figure D2 graphs some additional impluse responses. From Figure 5, we see that a tighter immigration policy leads to a decline in the fraction of immigrant workers that firms can employ at Home. This is reflected by a decline in the probability μ of being able to hire a skilled immigrant worker. The reduction in the stock of domestically available skilled labor leads to a rise in Home skilled wages, which causes domestic firms to substitute for Foreign labor through an increase in offshoring. However, because of the iceberg offshoring costs and relatively lower productivity in Foreign, firms do not completely substitute immigrant labor with offshore labor. Therefore, the increase in offshore labor does not offset the decline in immigrant labor, and the total output produced by the intermediate sector in Home falls, which leads to lower firm profits. Additionally, Home unskilled wages fall due to lower demand for unskilled labor by final good producers as unskilled labor and skill-intensive intermediate goods are complementary in the production function. In the Foreign economy, a larger available supply of skilled labor leads to lower skilled wages. On the other hand, a larger labor supply also implies a larger demand for the Foreign consumption good, which leads to a higher demand for Home and Foreign intermediate inputs and higher unskilled wages in Foreign.

In summary, when firms adjust the level of offshoring in response to a stricter immigration policy, part of the decline in skilled immigrant labor is offset by an increase in labor hired offshore, which is consistent with the empirical evidence.

To gain some insights regarding the importance of the offshoring channel, we study the responses to the same immigration policy change after fixing the level of offshoring to the initial level in the baseline case before the cap change. Therefore, in the second case, we shut down the adjustment

[26] For the perfect foresight solution, transition dynamics from the initial equilibrium to the final equilibrium are found by solving the model as a nonlinear, forward-looking, deterministic system using a Newton-Raphson method, as described in Laffargue (1990). This method simultaneously solves all equations for each period, without relying on low-order, local approximations.

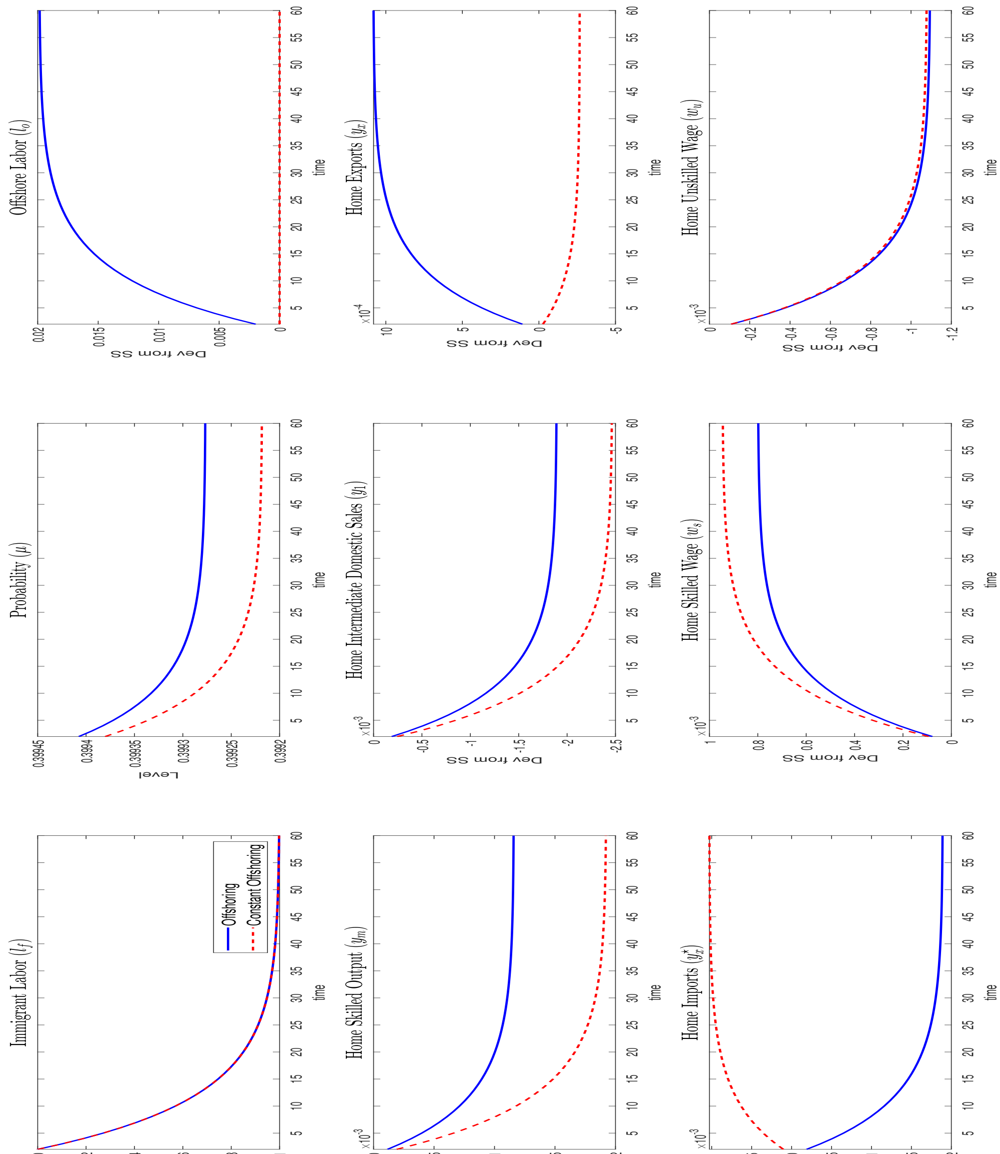

Figure 5: Response to a 10% Immigration Cap Reduction I: Offshoring Change versus Constant Offshoring. All deviations are in units of percent deviation from the steady state.

in offshoring and study the economy's responses to a 10% immigration cap reduction. The red dashed lines in Figures 5 and D2 plot the responses. From Figure 5 we see that while the stock of immigrant skilled labor declines in both the baseline case (solid blue line) and the constant offshoring case (red dashed line), the offshore labor hired adjusts only in the first case. Since firms do not adjust their offshoring level in the second case, domestically produced intermediate output falls by more. Moreover, Home skilled wages rise by more. Figure D2 shows that when we shut down the adjustment in offshoring, Foreign intermediate skilled output (produced by non-affiliated firms) rises by more as they are able to employ more skilled foreign labor. However, in the baseline case, more Foreign skilled labor gets employed in the offshore affiliated firms following the decline in the immigration cap, and Foreign non-affiliated firms are not able to expand as much.

As discussed in Section 5, the impact of offshoring on imports depends on whether or not we consider the adjustment in offshore labor hiring. As seen in Figure 5, there is a similar qualitative difference in the impact on domestic exports. Therefore, the impact of immigration on trade crucially depends on the offshoring channel. For the case in which firms do not adjust offshoring, domestic exports fall, and imports from the non-affiliates increase. This is because domestic production of intermediate goods falls after a tighter skilled immigration policy. However, when we do account for the adjustment in offshoring, domestic exports increase and imports from non-affiliated firms fall, even though there is an increase in imports from affiliates as a more significant part of the output is produced offshore. Imports from Foreign non-affiliated firms fall as more foreign skilled labor is employed in offshore affiliates, and labor employed in foreign non-affiliated firms falls, which leads to lower output produced in Foreign non-affiliated firms. Therefore, domestic intermediate firms are relatively more competitive than Foreign intermediate firms when firms adjust offshore labor hiring. This leads to a decrease in imports from non-affiliates and an increase in exports from domestic intermediate firms.

8.2 Welfare Analysis

8.2.1 Immigration Policy Change

We calculate welfare impacts after a 10%, perfect foresight reduction in the immigration cap. The welfare gain or loss for each type of domestic household from the immigration policy tightening is computed as the percentage change (Δ) in initial steady-state consumption that would leave the households indifferent between the initial policy and the new policy with the lower cap when the new policy is implemented at time $t = 0$. Transitional dynamics have been included in welfare computations. Thus, Δ solves:

$$u\big((1 + 0.01\Delta)C_j\big) = (1 - \beta)\sum_{t=0}^{\infty} \beta^t u\big(C_{j,t}\big), \quad \forall j \in \{d, u\}.$$

Table 4: Welfare Impact of 10% Immigration Cap Reduction

Home Households	Skilled	Unskilled	Entrepreneurs
Panel A. Baseline model: profit earners – home skilled workers			
Benchmark – offshoring	−0.0099	−0.0773	
Counterfactual – constant offshoring	−0.0088	−0.0762	
Panel B. Alternative model: profit earners – entrepreneurs			
Benchmark – offshoring	0.0564	−0.0773	−0.0702
Counterfactual – constant offshoring	0.0668	−0.0762	−0.0776

Note: Values reported above are in percent of initial steady-state consumption.

From Panel A in Table 4, we note that under the baseline model where native skilled households get firm profits, a 10 percent immigration cap reduction leads to approximately a net 0.01% decline in native skilled welfare.[27]

Intuitively, a stricter domestic skilled immigration policy leads to higher domestic skilled wages but lower firm profits. The welfare of domestic skilled workers falls because the decline in firm profits outweighs the increase in skilled domestic wages. In order to separate out the effects on wages and profits in the welfare calculations, we analyze the welfare effects of an alternate profit distribution scenario in Panel B of Table 4. For the alternate profit distribution scenario, we introduce a new type of household, the entrepreneurs. The entrepreneurs own the firms and therefore are profit earners. Their budget constraint is given by $C_{e,t} = d_t$, and the new Home skilled household's budget constraint is $C_{s,t} = w_{s,t}$. Therefore, the new stochastic discount factor for the firms is $\beta_{k,t} \equiv \beta[u'(C_{e,k})/u'(C_{e,t})]$.

The alternate profit distribution scenario results confirm our intuition that domestic skilled workers experience higher wages and welfare gains, while firm owners experience a welfare loss despite adjustment in offshoring, which offsets some of the firm losses. As mentioned before, iceberg trade costs and lower productivity in Foreign prevent them from a 1:1 adjustment in offshoring after an immigration cap reduction. From Panel B of Table 4, we see that the welfare gain from a 10% immigration cap reduction to domestic skilled workers due to higher wages is approximately 0.056%, while the loss to entrepreneurs due to lower profits is approximately −0.07%.

In both profit distribution cases, the welfare loss to domestic unskilled households is −0.0773%. Unskilled workers at Home are hurt after a skilled immigration cap reduction due to the decline in domestic consumption demand, leading to a decrease in demand for unskilled labor and unskilled wages.[28]

[27] It is important to note that a 10% cap increase corresponds to only roughly 8500 fewer skilled workers every year which amounts to roughly $0.9 \times 8500 \times 10 = 76,500$ fewer workers over ten years. However, if we were to consider large cap changes, for instance, a 200 percent increase in the cap, it would translate to lifetime gains of approximately 0.2% gain for skilled domestic workers' and a 1.5% gain for unskilled workers. To put things in perspective, a 200% cap increase would amount to an approximate annual entry of 255,000 skilled immigrants which would translate into 2,295,000 more workers over 10 years (accounting for exit), which is approximately 25.6% of the workers employed in the Professional, Scientific, and Technical Services sector in 2018 (BEA employement data).

[28] The complementarity between skilled and unskilled workers in the model arises from the final good consumption basket.

Through this analysis, our counterfactual exercise intended to emphasize the importance of accounting for the adjustment in offshoring by domestic firms after a change in immigration policy. Therefore, we also compute welfare impacts for the case where we keep the level of offshoring constant, following a cap change, i.e., we shut down the adjustment in offshoring.[29] We expect that if we do not account for the change in the offshoring level, firms are likely to be hurt more by the cap reduction, and Home skilled households are likely to gain more because of higher pressure on skilled domestic labor markets and a larger increase in wages. We can confirm this when we separate the welfare effects on domestic skilled workers and entrepreneurs in Panel B of Table 4. In the counterfactual case where we keep the level of offshoring constant, the gain to domestic skilled workers is approximately 18.4% higher than in the baseline case where firms adjust their offshore labor hiring. Therefore, we would estimate a greater increase in domestic skilled wages after an immigration cap reduction if we ignore the offshoring channel. Our results highlight the importance of accounting for the adjustment in offshoring when studying the impact of immigration policy changes as we would be exaggerating the welfare benefit to skilled workers if we do not account for this channel. Domestic entrepreneurs also lose by more when they do not adjust offshore labor hiring — their welfare loss is approximately 11% higher in the counterfactual case where we shut down the adjustment in offshoring.

To summarize, a stricter skilled immigration policy hurts unskilled workers and entrepreneurs but benefits skilled domestic workers because of higher wages. However, the gains to skilled domestic workers are overestimated if we do not account for offshore labor hiring adjustment following the stricter immigration policy. Therefore, it is important to consider the offshoring channel when evaluating skilled immigration policy changes' welfare effects.

8.2.2 Trade and offshoring Cost Changes

Given the increasing global trends towards protectionism in trade and re-nationalization of global supply chains, we analyze the impact of stricter trade policies. Since we have two trade channels (between affiliates and non-affiliates), we study three different policy changes. First, we study the effect of a stricter offshoring policy that would make it costlier for multinationals to import output back from affiliated firms in the foreign economy. To do this, we study the impact of a 1% increase in the iceberg offshoring cost (τ_o). Second, we study the effect of a stricter overall trade policy that would affect exports and imports between non-affiliated foreign and domestic firms. For this exercise, we consider the impact of a 1% increase in the iceberg trade cost (τ). This would make it costlier to export and import intermediate goods and affect both the domestic skilled intermediate and the final good sectors. Finally, we consider a policy change that increases both the trade and offshoring costs by implementing a 1% increase in both τ and τ_o.

The welfare implications are detailed in Table 5. Panel A includes results in the baseline model where domestic skilled households earn firm profits, while Panel B separates the results for workers

[29] We keep the calibration the same as the benchmark model. However, we keep the level of offshoring fixed at the initial steady-state level before the change in the cap.

Table 5: Welfare Impact of 1% Increase in Trade or Offshoring Costs

Home Households	Skilled	Unskilled	Entrepreneurs
Panel A. Baseline model: profit earners – home skilled workers			
Offshoring costs only	−0.0065	−0.0048	
Trade costs only	−0.0789	−0.0792	
Trade and offshoring costs	−0.0866	−0.0852	
Panel B. Alternative model: profit earners – entrepreneurs			
Offshoring costs only	0.1768	−0.0048	−0.1733
Trade costs only	−0.1114	−0.0792	−0.0492
Trade and offshoring costs	0.0622	−0.0852	−0.2220

Note: Values reported above are in percent of initial steady-state consumption.

and firm owners by adding an entrepreneur household, similar to Section 8.2.1. The welfare results indicate that higher offshoring and/or trade costs hurt both wage and profit earners. An important exception is the wage gain to domestic skilled households after an increase in offshoring costs, as seen in Panel B. Higher costs of offshoring incentivize firms to produce a larger component of their output domestically, which increases the demand for skilled workers in the Home country. Since the supply of domestic skilled workers is inelastic and the immigration cap is fixed, there is pressure on skilled wages at Home to increase, which leads to wage gains for domestic skilled workers. However, the total output produced in the domestic intermediate goods sector falls, and domestic firms lose due to lower profits. Moreover, the losses to firms outweigh the gains to domestic skilled workers — domestic skilled households witness overall welfare losses in the baseline model (Panel A of Table 5).

A stricter trade policy unambiguously hurts all domestic households — skilled, unskilled, and entrepreneurs, when offshoring policy is unchanged. This is the case even when we separate out entrepreneurs in order to study the effects on wages and profits separately in Panel B of Table 5. Domestic skilled wages, unskilled wages, and firm profits fall, which generates a welfare loss to households. An increase in the iceberg trade cost hurts the final goods sector and reduces imports. The domestic intermediate good sector is not as badly hurt in this case since domestic sales increase. However, since foreign skilled wages fall, domestic firms end up increasing their offshore labor hiring, which reduces domestic skilled wages. Unskilled wages at Home also fall due to a lower overall basket of skilled intermediate used in final goods production. There is also a decrease in final goods sector profit. In the third case that combines the effects of the previous two cases (simultaneously higher trade and offshoring costs), the net effect is unsurprisingly higher losses to skilled and unskilled households. However, in this case, Panel B indicates that when we separate out workers and entrepreneurs. We see overall gains to domestic skilled workers due to higher wages (caused by higher offshoring costs).

In summary, stricter trade and/or offshoring costs, in general, seem to hurt domestic households. However, the magnitudes and the channels depend on the which policy is implemented, and the interaction between trade and offshoring.

9 Conclusion

This paper introduces a two-country dynamic general equilibrium model with skilled immigration, offshore labor hiring, and trade in skill-intensive intermediate inputs. We solve the model analytically and then employ the calibrated model to study the interaction between skilled immigration policy changes in the U.S. and offshore labor hiring. In the model, a lower skilled immigration cap increases offshoring at the intensive margin. We show that it is crucial to consider firm adjustments in offshore labor hiring following an immigration policy change. In particular, if we do not account for an adjustment in offshoring, we would overestimate the positive effect on wages of domestic skilled workers after an immigration cap decline. Much of the current literature has ignored this channel when evaluating the welfare impact of skilled immigration policy changes. However, given recent debates surrounding stricter skilled immigration policies, it has become even more important to consider firm responses that would potentially offset the impact of the policy changes.

We also show that it is essential to account for firm adjustment in offshoring following an immigration policy change when evaluating the impact of immigration on trade. The paper highlights the importance of considering the general equilibrium relationships between migration, trade, and offshoring when designing immigration and trade policy changes. The model is a first step in studying these interactions in a macroeconomic general equilibrium framework.

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Appendix

A H1-B Program: Institutional Framework and Background

Since the implementation of the H1-B visa program in 1990, it has been the main method of entry into the U.S. workforce for foreign college educated professionals. Table A1 shows that H1-B visa holders constituted 66 percent of all skilled foreign entrants in 2014. A significant proportion of H1-B recipients (over 70 percent) are from emerging economies — India and China. The other major visa categories for foreign skilled workers are L-1 (for transfer of employees across multinational firms) and TN (visas for Canadian and Mexican NAFTA professional workers). The proportion of entrants from the latter two visa categories has been increasing since 2001, but the H1-B visa program still remains the dominant entry mode. Thus, most studies that analyze the impact of skilled foreign workers in the U.S. focus on the H1-B visa program. Though the H-1B visa is a temporary visa, issued for three years (and can be renewed for another three years), it is a dual intent visa as it can lead to permanent residency if the employer is willing to sponsor the worker for a green card.

Table A1: Major Entry Routes for Foreign Skilled Workers (2014)

	Visa Category		
	H1-B	L-1	TN
Proportion of Total	66.1 %	29.3 %	4.6 %

Source: U.S. Department of State

The H1-B program has been subject to an annual quota on new visa issuances. The initial visa cap was 65,000, which was subsequently increased to 115,000 in 1999 and 2000, after the cap was met in 1997. The cap was further increased to 195,000 for 2001 through 2003. In 2001, cap exemptions were introduced for higher education employees, non-profit, and government research organizations. In 2004, the cap was reduced back to 65,000, but 20,000 additional visas were allocated for workers who had obtained a Master's degree or higher from a U.S. institution. The cap applies only to new H1-B visa issuances for for-profit firms.

In order to obtain an H1-B visa, there are several steps to be followed, and firms are central to this process. The first step requires the firm that wants to hire a foreign worker to file a Labor Condition Application (LCA) with the department of labor. In the application, the firm specifies the nature of occupation and attests that the firm will pay the worker the greater of the actual compensation paid to other employees in the same job or the prevailing compensation for that occupation. The rationale given for this attestation is to help protect domestic worker wages.

LCA forms can request one or more foreign workers for a particular occupation, and thus they signal firm vacancies in specific occupations for foreign workers. LCAs are processed relatively quickly, and so firms can file them either after hiring workers or in anticipation of hiring. However, there are some limitations to using the LCA database. The LCA database contains records for every request submitted, but this is only an intermediate step in the process towards the final visa approval. An LCA is submitted for every H-1B request, whether new or a renewal, and each LCA can contain multiple H-1B workers. A more conservative estimate of the demand for foreign skilled workers would be to count each LCA filed as a request for one employee. Plotting the total number of LCAs filed as compared to Figure 1 that plots the total number of employees requested in LCAs filed each year does not change the main motivation regarding business cycle correlation and rising excess demand during expansionary periods.

Once the LCA has been approved by the Department of Labor, it is sent to the United States Citizenship and Immigration Services (USCIS), along with the I-129 form.[30] and the required visa fees. This is the final step, and firms have from April 1st until the beginning of the next fiscal year to file petitions for H1-B visa applications. The crucial fact is that employees can apply for an H1-B visa only if they have a job offer from an employer with an LCA approval. The employer cannot file more than one I-129 for the same prospective employee. The employer bears most of the filing and legal fees. If the number of H1-B visa petitions (I-129 forms) that fall within the non-exempt category exceeds the cap, the USCIS randomly selects visas for processing via a lottery system until the cap (65,000) is reached. The total number of petitions filed does not give an indication of the true demand because the government stops collecting H1-B petitions once it has determined that the cap has been reached for a given year. The filing fees paid for the unsuccessful visa applications are returned (unless it is discovered that multiple H1-B petitions are submitted for the same employee).

In recent months, the Department of Homeland security has been in the process of amending its regulations governing the process by which the U.S. Citizenship and Immigration Services (USCIS) selects H1-B petitions for the filing of the H1-B cap subject petitions. The proposed idea was to first select applications/registrations based on the highest Occupational Employment Statistics (OES) prevailing wage level. Firms that want to submit H1-B petitions would have to file a registration. When applicable, the USCIS will rank and select registrations based on wage levels. Effectively, even though there is still a cap on foreign workers, priority will be given to workers that are offered a higher wage within the relevant occupation category. The goal is to "incentivize H-1B employers to offer higher wages, or to petition for positions requiring higher skills and higher-skilled aliens that are commensurate with higher wage levels". However, the new administration has put the new ruling on hold for now.

[30] This proves the worker's qualifications

A.1 Sector-wise Average Demand for H-1B (2014-18)

Sector	Share of Total Avg. Foreign Worker Demand, 2014-2018 (%)
Professional, Scientific, and Technical Services	74.89
Manufacturing	8.49
Information	4
Finance and Insurance	2.86
Educational Services	2.58
Health Care and Social Assistance	1.99
Retail Trade	1.8
Administrative and Support and Waste Management and Remediation Services	1.09
Wholesale Trade	.66
Construction	.25
Management of Companies and Enterprises	.23
Transportation and Warehousing	.21
Other Services (except Public Administration)	.17
Accommodation and Food Services	.16
Real Estate and Rental and Leasing	.16
Mining, Quarrying, and Oil and Gas Extraction	.14
Utilities	.1
Arts, Entertainment, and Recreation	.09
Public Administration	.08
Agriculture, Forestry, Fishing and Hunting	.05

Notes: Authors' calculations using the Labor Condition Application (LCA) database for H1-B workers (Department of Labor)

B Home Intermediate Goods: Derivation of Optimality Conditions

Each firm optimally chooses $\rho_{1,t}$, $\rho_{x,t}$, $y_{1,t}$, $y_{x,t}$, $N_{e,t}$, $l_{f,t+1}$, $l_{o,t}$, and $l_{d,t}$, given the goods market clearing, domestic and foreign demand for intermediate inputs, and the law of motion for foreign skilled workers. Firms discount future real profits using skilled households' discount factor as they own the intermediate firms.

$$\mathbb{E}_t \sum_{k=t}^{\infty} \beta_{k,t} \Bigg\{ \rho_{1,k}(\omega) y_{1,k}(\omega) + Q_k \rho_{x,k}(\omega) y_{x,k}(\omega) \\ - f_{R,k} N_{e,k}(\omega) - w_{s,k} \left[l_{f,k}(\omega) + l_{d,k}(\omega) \right] - Q_k w^*_{s,k} \left[l_{o,k}(\omega) + f_{o,k}/Z^*_k \right] \Bigg\},$$

where the inter-temporal discount factor that the firm applies to its profits is $\beta_{k,t} \equiv \beta u'(C_{s,k})/u'(C_{s,t})$ since domestic skilled households are assumed to be the firm owners. A Home intermediate firm ω maximize expected discounted profits subject to:

1. $Z_t[l_{d,t}(\omega) + a l_{f,t}(\omega)] + Z^*_t l_{o,t}(\omega)/\tau_o = y_{1,t}(\omega) + \tau y_{x,t}(\omega)$
2. $y_{1,t}(\omega) = \left[\frac{\rho_{1,t}(\omega)}{\rho_{m,t}}\right]^{-\phi} m_t$
3. $y_{x,t}(\omega) = \left[\frac{\rho_{x,t}(\omega)}{\rho^*_{m,t}}\right]^{-\phi} m^*_t$
4. $l_{f,t+1}(\omega) = (1-\delta)\left[l_{f,t}(\omega) + \mu_t N_{e,t}(\omega)\right]$.

Let ψ_t, ζ_t, γ_t, λ_t, be the Lagrange multipliers on the constraints. The first order conditions with respect to $l_{f,t+1}$, $N_{e,t}$, $l_{o,t}$, $l_{d,t}$, $\rho_{1,t}$, $y_{1,t}$, $\rho_{x,t}$, $y_{x,t}$ are given by:

$$E_t \Bigg\{ \beta u'(C_{s,t+1}) \Big(- w_{s,t+1} + a\psi_{t+1} Z_{t+1} + (1-\delta)\lambda_{t+1} \Big) \Bigg\} - \phi_t u'(C_{s,t}) = 0 \tag{B1}$$

$$- f_{R,t} + \lambda_t (1-\delta)\mu_t = 0 \tag{B2}$$

$$- Q_t w^*_{s,t} + \psi_t \frac{Z^*_t}{\tau_o} = 0 \tag{B3}$$

$$- w_{s,t} + Z_t \psi_t = 0 \tag{B4}$$

$$y_{1,t} - \zeta_t \phi (\rho_{1,t})^{-\phi-1} m_t / (\rho_{m,t})^{-\phi} = 0 \tag{B5}$$

$$\rho_{1,t} - \psi_{1,t} - \zeta_t = 0 \tag{B6}$$

$$Q_t y_{x,t} - \gamma_t \phi (\rho_{x,t})^{-\phi-1} m^*_t / (\rho^*_{m,t})^{-\phi} = 0 \tag{B7}$$

$$Q_t \rho_{x,t} - \tau \psi_{1,t} - \gamma_t = 0 \tag{B8}$$

Combining Equations (B1) and (B2), we get:

$$\frac{f_{R,t}}{\mu_t} = (1-\delta)E_t\left\{\frac{\beta u'(C_{s,t+1})}{u'(C_{s,t})}\left(\psi_{t+1}aZ_{t+1}z - w_{s,t+1} + \frac{f_{R,t+1}}{\mu_{t+1}}\right)\right\} \tag{B9}$$

Combining Equations (B3) and (B4), we get:

$$\tau_o Q_t \frac{w^*_{s,t}}{Z^*_t} = \frac{w_{s,t}}{Z_t}. \tag{B10}$$

Using Equations (B9), (B10), and (B4), we can get Equation (11) in the main text. Combining Equations (B5) and (B6), we get:

$$\rho_{1,t} = \frac{\phi}{\phi-1}\frac{w_{s,t}}{Z_t} \tag{B11}$$

Combining Equations (B5) and (B6), we get:

$$\rho_{1,t} = \frac{\phi}{\phi-1}\frac{w_{s,t}}{Z_t} \tag{B12}$$

Combining Equations (B4), (B7), (B8), , and (B12) we get:

$$\rho_{x,t} = Q_t^{-1}\tau\rho_{1,t} \tag{B13}$$

C Model Summary

Table C2 shows have a system of 23 equations in 23 endogenous variables: $\{\rho_{m,t},\ \rho^*_{m,t},\ \rho_{1,t},\ \rho^*_{1,t},\ \rho_{x,t},\ \rho^*_{x,t},\ \mu_t,\ w_{s,t},\ w^*_{s,t},\ Q_t,\ l_{f,t+1},\ N_{e,t},\ l_{o,t},\ Y^c_t,\ Y^{c*}_t,\ w_{u,t},\ l^*_{s,t},\ w^*_{u,t},\ y_{1,t},\ y_{x,t},\ y^*_{x,t}, m_t, m^*_t\}$. Once we solve for these variables, we are able to solve for profits at Home and in Foreign as follows.

$$d_{1,t} = \rho_{1,t}y_{1,t} + Q_t\rho_{x,t}y_{x,t} - w_{s,t}(1+l_{f,t}) - Q_t w^*_{s,t}l_{o,t} - f_{R,t}N_{e,t} - f_{o,t}w^*_{s,t}Q_t/Z^* \tag{C14}$$
$$d_{c,t} = \rho_t Y^c_t - \rho_{1,t}y_{1,t} - N^*_d\rho^*_{x,t}y^*_{x,t} - w_{u,t}l_{u,t} \tag{C15}$$
$$d^*_{1,t} = \rho^*_{1,t}y^*_{1,t} + Q_t^{-1}\rho^*_{x,t}y^*_{x,t} - w^*_{s,t}l^*_{s,t} \tag{C16}$$
$$d^*_{c,t} = \rho^*_t Y^{c*}_t - N^*_d\rho^*_{1,t}y^*_{1,t} - \rho_{x,t}y_{x,t} - w^*_{u,t}\bar{l}^*_u \tag{C17}$$

C.1 Analytical Solution

Since our focus is on analyzing how changes in skilled immigration policies influence firms' offshoring decisions, this section gives some intuition regarding the relationship between the level of offshore labor hiring $l_{o,t}$ and the policy-imposed, skilled immigration cap at Home.

We can solve for $l_{o,t}$ explicitly. What helps us pin down this variable is the link between foreign and domestic skilled wages that is obtained through the offshoring condition: $w_{s,t}/Z_t = Q_t\tau_o w^*_{s,t}/Z^*_t$.[31]

Using this condition and the intermediate sector price setting equations (for $\rho_{1,t}$, $\rho_{x,t}$, $\rho^*_{1,t}$, and $\rho^*_{x,t}$), we can get the followings.

$$\rho_{1,t} = \frac{\tau_o}{\tau}\rho^*_{x,t} \tag{C18}$$
$$\rho_{x,t} = \tau_o\tau\rho^*_{1,t} \tag{C19}$$

[31] In the analytical solution, we allow for differences in the iceberg offshoring cost τ_o and trade cost τ.

Table C2: Baseline Model Summary

Equation Label	Equilibrium Condition
Home Intermediate Price Index	$(\rho_{m,t})^{1-\phi} = (\rho_{1,t})^{1-\phi} + N_d^*(\rho_{x,t}^*)^{1-\phi}$
Foreign Intermediate Price Index	$(\rho_{m,t}^*)^{1-\phi} = N_d^*(\rho_{1,t}^*)^{1-\phi} + (\rho_{x,t})^{1-\phi}$
Immigrant Labor Hiring Condition	$\frac{f_{R,t}}{\mu_t} = (1-\delta)\mathbb{E}_t\left[\beta_{t,t+1}\left(aw_{s,t+1} - w_{s,t+1} + \frac{f_{R,t+1}}{\mu_{t+1}}\right)\right]$
Immigrant Labor Stock	$l_{f,t+1} = (1-\delta)(l_{f,t} + \mu_t N_{e,t})$
Hiring Probability	$\mu_t = \bar{N}_{e,t}/N_{e,t}$
Balance of Payments	$Q_t\rho_{x,t}y_{x,t} - N_d^*\rho_{x,t}^*y_{x,t}^* = Q_tw_{s,t}^*l_{o,t} + Q_tf_ow_{s,t}^*/Z_t^*$
Home Intermediate Goods Market Clearing	$Z_t(1+al_{f,t}) + Z_t^*l_{o,t}/\tau_o = y_{1,t} + \tau y_{x,t}$
Foreign intermediate Goods Market Clearing	$Z_t^*l_{s,t}^* = y_{1,t}^* + \tau y_{x,t}^*$
Foreign Skilled Labor Market Clearing	$\bar{L_s}^* = N_d^*l_{s,t}^* + l_{f,t} + f_{o,t} + l_{o,t}$
Home Final Goods Market Clearing	$Z_tm_t^\alpha\bar{l_u}^{1-\alpha} = Y_t^c$
Foreign Final Goods Market Clearing	$Z_t^*m_t^{*\alpha}\bar{l_u^*}^{1-\alpha} = Y_t^{c*}$
Home Consumption price Index	$1 = (\frac{\theta}{\theta-1})(\frac{\rho_{m,t}}{\alpha})^\alpha(\frac{w_{u,t}}{1-\alpha})^{1-\alpha}/Z_t$
Foreign Consumption price Index	$1 = (\frac{\theta}{\theta-1})(\frac{\rho_{m,t}^*}{\alpha})^\alpha(\frac{w_{u,t}^*}{1-\alpha})^{1-\alpha}/Z_t^*$
Home Intermediate Domestic Price	$\rho_{1,t} = (\frac{\phi}{\phi-1})w_{s,t}/Z_t$
Home Intermediate Export Price	$\rho_{x,t} = Q_t^{-1}\tau\rho_{1,t}$
Foreign Intermediate Domestic Price	$\rho_{1,t}^* = (\frac{\phi}{\phi-1})w_{s,t}^*/Z_t^*$
Foreign Intermediate Domestic Price	$\rho_{x,t}^* = Q_t\tau{\rho_{1,t}}^*$
Home Intermediate Demand	$y_{1,t} = (\rho_{1,t}/\rho_{m,t})^{-\phi}m_t$
Foreign Intermediate Demand	$y_{1,t}^* = (\rho_{1,t}^*/\rho_{m,t}^*)^{-\phi}m_t^*$
Home Export Demand	$y_{x,t} = (\rho_{x,t}/\rho_{m,t}^*)^{-\phi}m_t^*$
Foreign Export Demand	$y_{x,t}^* = (\rho_{x,t}^*/\rho_{m,t})^{-\phi}m_t$
Home Unskilled Labor Market Clearing	$w_{u,t}\bar{l_u} = (1-\alpha)(\frac{\theta-1}{\theta})Y_t^c$
Foreign Unskilled Labor Market Clearing	$w_{u,t}^*\bar{l_u}^* = (1-\alpha)(\frac{\theta-1}{\theta})Y_t^{c*}$

This means that if $\tau_o < \tau$, the ability to offshore reduces the domestic price of the skilled intermediate compared to the imported intermediate. However, the domestic intermediate good's export price is still higher than the Foreign intermediary because of both the iceberg costs.

This relationship between domestic and import prices in each country links the demand for domestic and imported intermediate goods. Note that domestic and import demand for Home and Foreign intermediate goods is given by:

$$y_{1,t} = \left(\frac{\rho_{1,t}}{\rho_{m,t}}\right)^{-\phi} m_t \tag{C20}$$

$$y_{1,t}^* = \left(\frac{\rho_{1,t}^*}{\rho_{m,t}^*}\right)^{-\phi} m_t^* \tag{C21}$$

$$y_{x,t} = \left(\frac{\rho_{x,t}}{\rho_{m,t}^*}\right)^{-\phi} m_t^* \tag{C22}$$

$$y_{x,t}^* = \left(\frac{\rho_{x,t}^*}{\rho_{m,t}}\right)^{-\phi} m_t. \tag{C23}$$

Using Equations (C18). (C20), and (C23), we can get:

$$y^*_{x,t} = \left(\frac{\tau_o}{\tau}\right)^\phi y_{1,t} \tag{C24}$$

$$y^*_{1,t} = (\tau\tau_o)^\phi y_{x,t} \tag{C25}$$

We will be using these demand relationships in the solution. Implicit in the solution is that both countries have the same constant markups over marginal cost. Also, the offshoring optimality condition requires that the marginal cost of production at Home and in the offshore affiliate is the same across both countries. This also assumes that the Foreign skilled workers in the offshore affiliate and in the Foreign intermediate are paid the same skilled wages, i.e., perfect labor mobility between the two types of firms.

Consider the trade balance equation:

$$Q_t\rho_{x,t}y_{x,t} - N^*_d\rho^*_{x,t}y^*_{x,t} = Q_t w^*_{s,t}l_{o,t} + Q_t f_o\frac{w^*_{s,t}}{Z^*_t}. \tag{C26}$$

Substituting for prices, this can be written as:

$$Q_t\tau_o\tau\frac{\phi}{\phi-1}y_{x,t}\frac{w^*_{s,t}}{Z^*_t} - N^*_d Q_t\tau\frac{\phi}{\phi-1}y^*_{x,t}\frac{w^*_{s,t}}{Z^*_t} = Q_t w^*_{s,t}l_{o,t} + Q_t f_o\frac{w^*_{s,t}}{Z^*_t}, \tag{C27}$$

which can be simplified as:

$$\tau_o\tau y_{x,t} - N^*_d\tau y^*_{x,t} = \frac{\phi-1}{\phi}Z^*_t l_{o,t} + \frac{\phi-1}{\phi}f_o. \tag{C28}$$

Using Equation (C24), we get:

$$\tau_o\tau y_{x,t} - N^*_d\tau\left(\frac{\tau_o}{\tau}\right)^\phi y_{1,t} = \frac{\phi-1}{\phi}Z^*_t l_{o,t} + \frac{\phi-1}{\phi}f_o. \tag{C29}$$

Consider the Foreign intermediate goods market clearing:

$$Z^*_t(\bar{L}^*_s - l_{f,t} - f_{o,t} - l_{o,t})/N^*_d = y^*_{1,t} + \tau y^*_{x,t}. \tag{C30}$$

Using Equations (C24) and (C25), we can get

$$Z^*_t(\bar{L}^*_s - l_{f,t} - f_{o,t} - l_{o,t})/N^*_d = (\tau\tau_o)^\phi y_{x,t} + \tau\left(\frac{\tau_o}{\tau}\right)^\phi y_{1,t}. \tag{C31}$$

Equivalently,

$$\bar{L}^*_s - l_{f,t} - f_{o,t} - l_{o,t} = \frac{N^*_d}{Z^*_t}(\tau\tau_o)^\phi y_{x,t} + \frac{N^*_d}{Z^*_t}\tau\left(\frac{\tau_o}{\tau}\right)^\phi y_{1,t}. \tag{C32}$$

Also, consider Home intermediate goods market clearing:

$$Z_t(1 + a l_{f,t}) + Z^*_t l_{o,t}/\tau_o = y_{1,t} + \tau y_{x,t}. \tag{C33}$$

In this framework, the stock of skilled foreign workers is determined by the entry cap (as the cap is binding) as well as the exogenous probability of return. This is because $l_{f,t} = (1-\delta)(l_{f,t-1} + \mu_{t-1}N_{e,t-1})$ and $\mu_{t-1}N_{e,t-1} = \bar{N}_{e,t}$. Therefore we take $l_{f,t}$ as exogenous and solve for $l_{o,t}$ as a function of the stock of foreign skilled labor. Then, the system boils down to Equations (C29), (C32), and (C33) in three variables ($l_{o,t}$, $y_{1,t}$, $y_{x,t}$). These are summarized below:

$$\begin{aligned} \tau_o \tau y_{x,t} - N_d^* \tau \left(\frac{\tau_o}{\tau}\right)^{\phi} y_{1,t} &= \frac{\phi-1}{\phi} Z_t^* l_{o,t} + \frac{\phi-1}{\phi} f_o \qquad \text{(C34)} \\ \bar{L}_s^* - l_{f,t} - f_{o,t} - l_{o,t} &= \frac{N_d^*}{Z_t^*}(\tau\tau_o)^{\phi} y_{x,t} + \frac{N_d^*}{Z_t^*}\tau\left(\frac{\tau_o}{\tau}\right)^{\phi} y_{1,t} \qquad \text{(C35)} \\ Z_t(1+al_{f,t}) + Z_t^* l_{o,t}/\tau_o &= y_{1,t} + \tau y_{x,t}. \qquad \text{(C36)} \end{aligned}$$

These equations highlight the interlinkages between input demand (domestic and foreign), offshoring, and immigration (under the binding cap). By using them, we get the solution in Equation (13).

To show that the coefficients of Equation (13) associated to $\bar{L}_s^*$, $l_{f,t}$, f_o, and relative productivity Z_t/Z_t^* are positive, it is sufficient to show that $\Lambda - \Xi\tau^{2\phi-1} > 0$.[32] Since $\Lambda = \tau^{\phi-1}/(N_d^*\tau_o^{\phi})$ and $\Xi = \{\tau\tau_o[1+N_d^*(\tau\tau_o)^{\phi-1}]\}^{-1}$, we can get:

$$\Lambda - \Xi\tau^{2\phi-1} = \frac{\tau^{\phi-1}\tau_o^{-\phi}}{N_d^*\left[1+N_d^*(\tau\tau_o)^{\phi-1}\right]} > 0.$$

Therefore, we get that offshore labor hired $l_{o,t}$ is increasing in the availability of skilled labor in Foreign ($\bar{L}_s^*$), decreasing in the stock of immigrant skilled labor ($l_{f,t}$), decreasing in the fixed offshoring cost f_o, and decreasing in relative productivity at home Z_t/Z_t^*.

Further, we can solve for $y_{x,t}^*$ and $y_{1,t}$ as: Equation (14) and

$$y_{1,t} = \frac{1}{1+N_d^*(\frac{\tau}{\tau_o})^{\phi-1}}\left[Z_t(1+al_{f,t}) + \frac{Z_t^*}{\phi\tau_o}l_{o,t} - \frac{(\phi-1)}{\phi\tau_o}f_o\right]. \qquad \text{(C37)}$$

[32]This may not be sufficient for the coefficient on f_o if $Z_t^* > 1$ but we rule this out. We normalize $Z* = 1$ in the baseline calibration and calibrate Z^* accordingly.

D Additional Figures

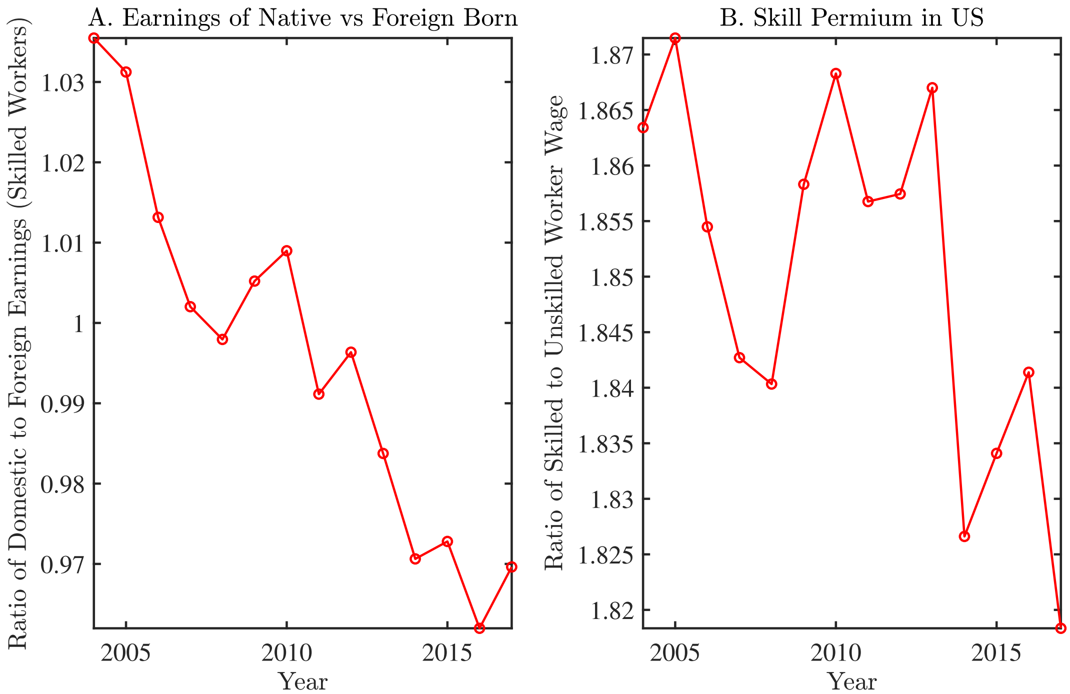

Figure D1: Immigrants' Earnings and Skill Premium 2004 – 2017

Notes: Authors' calculations using Current Population Survey monthly samples (accessed through IPUMs). Panel A shows trends on the ratio of weekly wages of native vs foreign-born workers. Panel B displays trends related to the skill premium (ratio of average skilled and unskilled wages). We define skilled as those individuals with a Bachelor's degree or higher and thus, unskilled as those without a Bachelor's degree.

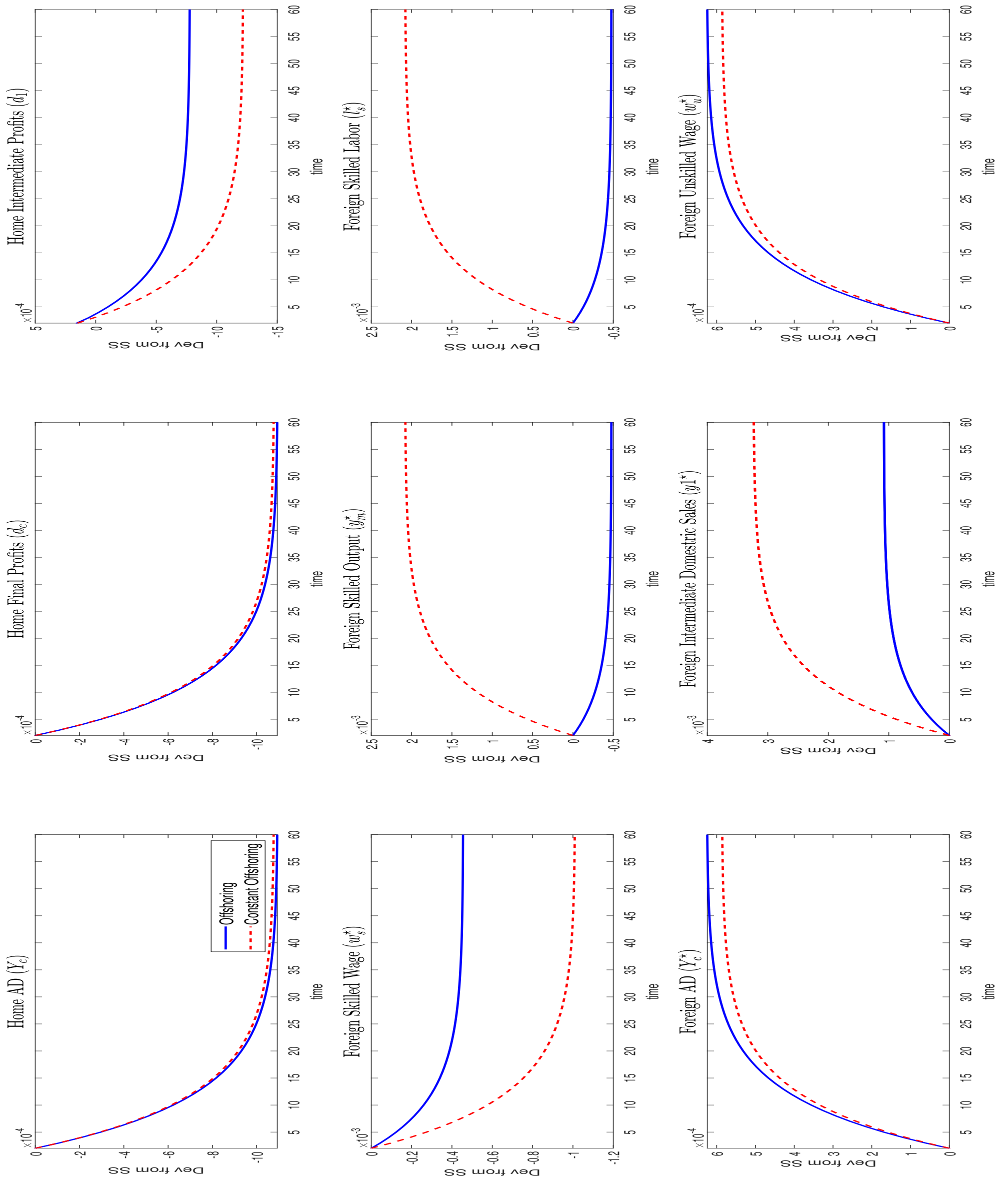

Figure D2: Response to a 10% Immigration Cap Reduction II: Offshoring Change versus Constant Offshoring. All deviations are in units of percent deviation from the steady state.