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Abstract

This paper analyzes how migration policy reforms shape migrants' self-selection and, through that, affect welfare and wage inequality in the sending and destination countries. First, we document that the distribution of wages among U.S. workers dominates the distribution of wages among Mexican immigrants in the hazard rate order. Second, we show that if this condition holds, then the standard assignment model predicts that the efficiency and equality goals of migration policy are in conflict. Finally, we develop and calibrate a two-country extension of the assignment model with endogenous migration, and use it to quantify the implications of migration policy reforms.

Keywords: Migration; Matching; Selection; Welfare; Inequality.
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1 Introduction

Immigrants do not make up a random sample of the population from the sending country; neither are workers randomly assigned to firms within countries. These two facts are closely connected: the distribution of skills among migrants affects which jobs are performed by the native-born workers, whereas the kinds of jobs offered to immigrants determines who decides to migrate. While the literature has long recognized the importance of *selection into migration* (Borjas, 1987; Chiquiar and Hanson, 2005; Moraga, 2011; Kaestner and Malamud, 2014; Borjas et al., 2018), research has been much slower to investigate the impact that migration has on the *within-country assignment of workers to jobs* (Peri and Sparber, 2009; Foged and Peri, 2016; Burstein et al., 2019), and has been silent on these interactions.

In this paper, we analyze the impact that migration has on the labor markets in sending and destination countries. The novelty of our approach is that we study how workers are sorted both across and within countries. We start by developing a one-country model that includes within-country sorting and exogenous migration, for which we are able to provide monotone comparative static results. We extend the model into a two-country setting, in which workers in the sending country self-select into emigration. The two-country model is then embedded into a tractable general equilibrium setup, in which agents consume domestically produced and internationally traded goods. Finally, we calibrate the two-country model and quantify the impact that more restrictive and more liberal U.S. immigration policies targeted towards Mexico have on the distributions of real wages for U.S. citizens, Mexican migrants, and Mexican stayers.[1]

Our one-country setting extends the standard assignment model of Becker (1973) and Sattinger (1979) to allow for the free entry of firms. We show that if the initial distribution of natives' skills dominates the distribution of migrants' skills in the hazard rate order, the efficiency and equality motives of migration policy are in direct conflict.[2] Specifically, we

[1]Throughout the paper, we refer to the non-Mexican workers that reside in the United States as "U.S. citizens." Of course, this designation is a simplification, as this broadly defined group consists not only of those workers born in the United States, but also migrants from other countries, and because some U.S. citizens live outside of the United States.

[2]Hazard rate order dominance implies that—for all wage levels—the ratio of the

show that if the overall skill distribution worsens due to immigration, then (a) for domestic workers the average wage increases and (b) wages fall for all workers with earnings below a certain cutoff; and *vice versa* if the overall skill distributions improves. This result relies only on the fact that the economy exhibits distance-dependent elasticities of substitution (DIDES, see Teulings, 2005), and thus workers with similar skills are substitutes, whereas workers with sufficiently different skills levels are complements.[3] If the overall skill distribution worsens, then new arrivals must *on average* be complements with natives, and the average wage of native workers increases. However, as the new arrivals are also substitutes with low-skilled native workers, the wages of these native workers necessarily go down.

We then apply this general insight when considering the case of Mexican migration to the United States. We observe that the wage distribution among Mexican migrants is worse than the wage distribution among U.S. citizens in the hazard rate order, implying that the same pattern holds for the skill distributions. It follows that the conflict between the equality and efficiency goals of migration policy is present in the US–Mexico case. This conflict does not, however, necessarily imply that a policy that increases the number of Mexican immigrants in the United States leads to an increase in wage inequality: changes in migration have a *share effect* and also a *composition effect*. The share effect keeps the migrants' skill distribution constant, but changes the share of migrants in the population: thus, the share effect of a more liberal migration policy must lead to a worsening of the skill distribution in the United States. The composition effect keeps the share of migrants constant, but varies their skill distribution: the sign of the composition effect depends on the specifics of the migration policy and on the initial selection patterns.

In order to determine the sign of the composition effect, we build a two-country assignment model that endogenizes the within-country supply of skills and firms by embedding the framework of Gola (2019) into a general equilibrium model with international trade. Workers are endowed

survival functions (with the dominant distribution in the numerator) is increasing.

[3]As average profits are constant, any change in the distribution of wages must hurt some workers and benefit others; and because matching is positive and assortative in the Sattinger (1979) assignment model, it follows that workers of similar skills perform similar jobs and are thus close substitutes (see Costrell and Loury (2004) for details).

with continuously distributed vectors of country-specific skills, and Mexican workers can decide whether to emigrate to the United States or remain in Mexico, exactly as in Roy (1951), Heckman and Sedlacek (1985), and Borjas (1987). Productivity is continuously distributed among firms and differs both within and across countries. High-productivity firms serve as complements to high-skilled workers. Consequently, workers match with firms positively and assortatively, as in Sattinger (1979), Dupuy (2015), and Mak and Siow (2017). The goods market is monopolistically competitive, and the supply of firms is endogenized in the same way as in Melitz (2003). All individuals exhibit love of variety over a continuous set of imperfectly substitutable consumption goods, following Dixit and Stiglitz (1977). All active firms serve domestic and foreign markets, as in Krugman (1980).

The model is calibrated to represent the U.S. and Mexican economies in 2015. The calibration reveals that emigrants and stayers are positively selected with respect to the U.S.- and Mexican-specific skill sets, respectively.[4] This finding has two immediate consequences. First, added to the fact that Mexican immigrants are less skilled than U.S. citizens, it implies that Mexican migration to the United States benefits the high-skilled U.S. citizens and the low-skilled Mexican stayers, but hurts low-skilled U.S. citizens and high-skilled Mexican stayers. Overall, 55 percent of U.S. citizens and 50 percent of Mexican stayers gain from Mexican emigration to the United States. Second, it implies that a decrease in the monetary cost of migration attracts Mexicans who are less skilled according to the U.S.-specific skill than the current migrants (Borjas, 1987; Heckman and Honoré, 1990), thus contributing to the worsening of the overall skill distributions. Hence, the composition effect of a fall in the monetary cost of migration has the same sign as the share effect, and both the average wage and the variance of (log) wages increase. Specifically, a 200 USD fall in the cost of a U.S. visa increases (a) the share of Mexican immigrants from 4.9 to 5.2 percent, (b) the average wage of U.S. citizens by 5 USD (0.01 percent) and

[4] In the language of Heckman and Honoré (1990) this means that both countries are "standard." In the language of Borjas (1987) the economy exhibits "refugee sorting." Note, however—in contrast to Borjas (1987)—we do not assume that the marginal skill distributions among Mexican and U.S. citizens are the same, and thus refugee sorting need not imply that Mexican migrants earn more than U.S. citizens.

(c) the standard deviation of log wages by 0.03 percent.

Finally, we explore whether the tension between the efficiency and equality goals of U.S. migration policy can be mitigated by changes in taxation policy. We find that there are "left-wing" and "right-wing" policy measures that increase the average income and lower income inequality among U.S. citizens. The "left-wing" policy combines a decrease in the cost of migration and more income redistribution among natives. The "right-wing" policy imposes a tax on Mexican immigrants (or an increase in visa costs), the proceeds from which are then redistributed among the U.S. citizens through a lump sum transfer.

The emerging literature that studies the distributional impact of migration with models using within-country sorting treats the decision to migrate as exogenous (Peri and Sparber, 2009; Choi and Park, 2017; Burstein et al., 2019). Our main contribution to this work is allowing for endogenous migration choices, as these endogenous changes in migrants' selection turn out to be quantitatively important—we find that if the price effects are eliminated, the composition effect is responsible for 40 to 55 percent of the overall change in the average wage of U.S. citizens in response to a fall in U.S. visa costs. It is the tractability of the assignment model that allows us to both endogenize migration choices and derive monotone comparative statics results regarding changes in average wages and wage inequality. Although the model in Burstein et al. (2019) explicitly refers to occupations, it is only tractable when skills are Fréchet distributed. This distributional assumption precludes both any meaningful study of the impact that migration has on wage inequality (as this assumption implies that the variance of log wages is constant) and makes it difficult to endogenize cross-border migration (as the distribution of wages is equal across all countries).

Second, we contribute to the literature on selection into immigration, started by Borjas (1987), by developing a model that allows for complementarity in wages between high- and low-skill workers and for fully general selection patterns.[5] These features of the model are crucial for two reasons. First, only in the presence of complementarity between workers, changes in

[5]The only other paper that develops a model with both of these features is Gola (2019), on which we build here. However, the complementarity between high- and low-skilled workers appears only in an extension of that model, and its focus is not on selection into migration.

migrants' skill distribution produce distributive wage effects. Second, the initial selection patterns determine the impact that migration policies have on migrants' skill distribution. However, the literature tends to restrict attention to the case of perfect correlation of skills across countries by imposing constant elasticity of substitution (CES) model.[6] This assumption is not only inconsistent with empirical evidence, but also overly restrictive.[7] The main insight derived by the literature on self-selection is precisely that selection patterns depend on (a) the variance of wages in both countries and (b) the correlation between the skills used in the two countries. Indeed, the sorting pattern that emerges in our calibrated model cannot be produced under the assumption of perfectly correlated skills.

By deriving monotone comparative statics results with respect to exogenous changes in the skills distribution we make a twofold contribution to the literature (Costrell and Loury, 2004; Costinot and Vogel, 2010; Dustmann et al., 2013). First, our model allows for the presence of unemployment: we find that the condition needed for the derivation of monotone comparative statics in our model (the hazard rate order) is stronger than in an assignment model without unemployment (first-order stochastic dominance, as in Costrell and Loury, 2004) but is still weaker than in an assignment model with endogenous firm sizes (the monotone-likelihood ratio, as in Costinot and Vogel, 2010). Second, we are the first to derive results for changes in the average wage of a subgroup of the population (the natives) in response to exogenous changes in the skill distributions, findings which conditions are necessary for establishing the conflict between the equality

[6]The CES model is incompatible with the standard method used in the self-selection literature to determine the distribution of workers' skill levels in each country (the separation function). This incompatibility is a consequence of the fact that the CES model lacks a natural ranking of skills: as workers are pre-assigned to jobs, wages are not necessarily increasing in worker's skills (low-skilled workers, if in scarce supply, can earn more than high-skilled workers).

[7]In frictionless economies, the perfect correlation of skills across countries implies that migrants who occupied the same wage quantile in the sending country (prior to migration) also must occupy the same wage quantile in the destination country (after migration). Generically, however, this is not the case, as the returns to various dimensions of skills are likely to differ across countries (e.g., one may earn a high wage in Mexico without proficiency in English, an outcome which is unlikely to happen in the United States). These varying returns mean that univariate skill indexes are imperfectly correlated. In particular, Table A3 in Hanushek et al. (2015) documents significant differences in returns to numeracy, literacy and problem solving skills across countries.

and efficiency goals of migration policy.[8]

Overall, we construct a model that determines equilibrium wage distributions in the sending and destination countries subject to changes in migration, trade and redistributive policies. This model uses a general equilibrium setup that enables us to draw new conclusions about the economic implications of international migration that have been highlighted in the recent literature. First, we discuss the *labor market effect* of migration (Card, 2001, 2009; Borjas, 2003; Ottaviano and Peri, 2012; Dustmann et al., 2013; Llull, 2018), along the whole skill distributions in both countries. Second, assuming that all individuals reveal love of variety and consume horizontally differentiated baskets of goods, the change in the mass of firms in the market impacts real wages through the *market size effect* (i.e., changes to the ideal price index, as in Krugman, 1980), that is investigated in Iranzo and Peri (2009), di Giovanni et al. (2015), Aubry et al. (2016), and Biavaschi et al. (2020). Third, macroeconomic shocks are propagated through *trade* linkages, as migration affects the terms of trade. We extend the literature considering the regional (Allen and Arkolakis, 2014; Redding and Rossi-Hansberg, 2017; Burstein et al., 2019) and international context (di Giovanni et al., 2015; Burzyński, 2018; Heiland and Kohler, 2019) by investigating the impact of migrants' self-selection on trade patterns within a rich set of counterfactual policy scenarios.

The rest of the paper is organized as follows. Section 2 develops and analyzes the one-country model. Sections 3 and 4 discuss the two-country model and its numerical calibration. In Section 5, we analyze the welfare and inequality consequences of changes to migration and trade costs between Mexico and the United States. Section 6 concludes.[9]

[8]Proposition 7 in Costrell and Loury (2004) and Appendix A in Dustmann et al. (2013) show that in a world with zero migration, the average wages of native workers are lower than in a world with some migration (under perfect capital mobility). This result is different from ours—we show what happens to the average wage of natives in response to changes in migration even if migration was non-zero initially.

[9]Proofs of all statements are available in Online Appendix A. Online Appendix C provides details of the calibration procedure, Online Appendix D reports the results of several robustness checks and Online Appendix E compares numerically how wages change in response to a supply shock in the assignment and CES models.

2 One-Country Model

In this section we extend the assignment model of Becker (1973) and Sattinger (1979) to allow for the free entry of firms, and show that—absent composition effects—a more liberal U.S. migration policy would result in an increase in the average wage of U.S. citizens, but at the cost of increased wage inequality in the United States.[10]

2.1 The Model

Consider an economy endowed with three populations: native workers (N), migrant workers (M), and firms. Each worker is endowed with a skill $x \in [0,1]$. The measure of workers from population $i \in \{N, M\}$ is denoted by R_i^W, and their skill distribution $G_i : [0,1] \to [0,1]$ is continuously differentiable and has full support. The overall skill distributions is denoted by G, and is a mixture of native and migrant skill distributions, with $G(x) = \alpha G_M(x) + (1-\alpha)G_N(x)$ and $\alpha \equiv R_M^W/(R_N^W + R_M^W)$. Workers can either receive a market wage from a firm, or remain unemployed and receive a reservation wage w^c.

There exists an unlimited supply of *ex ante* identical firms. A firm that decides to enter the market incurs a fixed cost of entry $c^e > 0$ and draws its productivity h from a standard uniform distribution. The measure of all firms that enter the market is denoted by R^F. Once their type is known, firms decide whether to remain active and produce, or to exit the market. Active firms employ a single worker whom they pay the competitive wage for the skill she provides. If a firm of type h hires a worker with skill x, they produce a revenue of $r(x,h)$. We assume that $\partial r/\partial x, \partial r/\partial h, \partial^2 r/\partial x \partial h$ exist and are strictly positive and continuous, so that the revenue function is strictly increasing and supermodular in the worker's skill and the firm's productivity. We further assume that $r(0,h) < 0$, which means that the least-skilled workers will never be hired.

Demand, Supply and the Equilibrium Fixing the measure of firms in the market (i.e., for a given R^F), the demand for skills is determined by

[10] Equivalently, we extend the Costrell and Loury (2004) assignment model to allow for endogenous unemployment of workers.

the firms' hiring decisions, which in turn are driven by profit maximization, with firms taking the wage function $w : [0,1] \to \mathbb{R}$ as given. Denote the operating profit of firm h by $\pi(h)$ and the skill of the worker it hires by $\mu(h)$. The operating profit is equal to the revenue net of the wage paid to the worker, with

$$\pi(h) = \max_{x\in[0,1]} \; r(x,h) - w(x), \qquad \mu(h) \in \arg\max_{x\in[0,1]} \; r(x,h) - w(x). \tag{1}$$

The *demand for skill* x, $D(x)$, is equal to the measure of firms that, given the wage function w and firm measure R^F, hire workers with a skill level of at least x:

$$D(x) \equiv R^F \cdot \Pr\left[\mu(H) \geq x, \pi(H) \geq 0\right].\text{[11]} \tag{2}$$

The expected operating profit is $\pi^E = \int_0^1 \max\{\pi(h), 0\}\, \mathrm{d}h$. Firms enter only if their expected profits (i.e. the expected operating profit net of entry cost) are weakly positive: In equilibrium, if entry is positive then $\pi^E = c^e$.

Workers also take the wage function w as given and decide whether to work or remain unemployed. Thus, the supply of skill x, S, which is defined as the measure of active workers with a skill level greater than x, is given by:

$$S(x) \equiv (R_N^W + R_M^W) \cdot \Pr\left[X \geq x, w(X) > w^c\right]. \tag{3}$$

In equilibrium, the demand for a skill must be equal to its supply, and firms must earn zero expected profits. The equilibrium exists and is unique.[12]

2.2 Wages

The inverse of the hiring function μ will be called the *matching function* and is denoted by m: a worker with skill x matches with the firm $m(x)$, and they jointly generate revenue $r(x, m(x))$. It is well-known (Becker, 1973;

[11]Because revenue increases strictly in firm's type, so will profit—thus firms with $\pi^E(h) = 0$ are of measure zero.

[12]For a given $R^F > 0$ the existence follows from the standard results. It is easy to show that π^E is continuous and strictly decreasing in R^F, which proves the equilibrium's existence and uniqueness, respectively.

Sattinger, 1979) that with supermodular revenue functions, matching must be positive and assortative (PAM); that is, the matching function must be strictly increasing. This condition and market clearing immediately give

$$m^*(x) = 1 - S(x)/R^F \text{ for } x \geq x^c, \tag{4}$$

where x^c denotes the skill of the least-skilled employed worker, and solves $r(x^c, m(x^c)) = w^c$.[13] The first-order condition of the firm's hiring decision implies that

$$\partial w(\mu(h))/\partial x = \partial r\Big(\mu(h), 1 - S(\mu(h))/R^F\Big)/\partial x. \tag{5}$$

The difference in wages paid to workers of marginally different skill is equal to the difference in the revenue they produce, evaluated for the firm that is the optimal match for one of them. Integrating from x^c to x gives

$$w(x) = \int_{x^c}^{x} \partial r(z, 1 - S(z)/R^F)/\partial x \, \mathrm{d}z + w^c \qquad \text{for } x \geq x^c.\text{[14]} \tag{6}$$

Finally, note that $S(x) = (R_D^W + R_M^W)(1 - G(x))$ for $x \in [x^c, 1]$, since the wage function is strictly increasing on that interval.

2.3 Comparative Statics

We will now study how a worsening of the overall skill distribution (caused either by a change in R_M^W or G_M) affects the average welfare and wage inequality of U.S. citizens. Specifically, we compare the equilibria of two specifications of the model: the *old* one and the *new* one. The old specification is denoted by ρ_1 and the new one by ρ_2.[15]

Definition 1. The distribution $G(\rho_1)$ is better than the distribution $G(\rho_2)$

[13]Because of market clearing and the fact that the revenue function strictly increases in firm type, it follows that under equilibrium wages $h < (>) m(x^c)$ implies that $\pi(h) < (>) 0$. As μ is strictly increasing, market clearing allows us to write $S(x) = D(x) = R^F(1 - m^*(x))$.

[14]The market wage is not uniquely determined for unemployed workers, but must satisfy $w(x) \geq w(x^c) + r\Big(x, 1 - S(x^c)/R^F\Big) - r\Big(x^c, 1 - S(x^c)/R^F\Big)$. For notational simplicity, we will adopt the convention that $w(x) = w^c$ for $x < x^c$.

[15]For example, $G(\rho_1)$ is the old skill distributions and $G(\rho_2)$ is the new one.

in the hazard rate order ($G(\rho_1) \geq_{hr} G(\rho_2)$) if and only if $\bar{G}(x;\rho_1)/\bar{G}(x;\rho_2)$ is increasing in x, where $\bar{G}(x;\rho_i) \equiv 1 - G(x;\rho_i)$ denotes the survival function of distribution $G(x;\rho_i)$.

Note that the hazard rate order implies first-order stochastic dominance and is itself implied by the monotone-likelihood ratio property (see Theorems 1.B.1. and 1.C.1. in Shaked and Shanthikumar, 2007).

Proposition 1. Suppose that $G_N \geq_{hr} G(\rho_1) \geq_{hr} G(\rho_2)$. Then (i) there exists some $\bar{x} \in (\max_i x^c(\rho_i), 1)$ such that $w(x;\rho_2) \geq w(x;\rho_1)$ if $x \geq \bar{x}$ and $w(x;\rho_2) \leq w(x;\rho_1)$ if $x \leq \bar{x}$; and (ii)

$$\int_0^1 w(x;\rho_2)\,\mathrm{d}G_N(x) \geq \int_0^1 w(x;\rho_1)\,\mathrm{d}G_N(x).$$

Proposition 1 (i) states that if the overall skill distribution worsens in the hazard rate order sense, then there exists a cutoff level of skills, such that wages increase for all workers with skill greater than the cutoff level and fall otherwise. To understand the mechanics behind this result in more detail, it is instructive to consider the case in which there was no immigration initially ($R^W_M(\rho_1) = 0$). First, note that $G_N \geq_{hr} G(\rho_2)$ implies that the distribution of native skill dominates the distribution of migrant skill in the hazard rate order. Consider what happens to the matching function in response to the influx of migrants; for any $x \in (\max_i x^c_U(\rho_i), 1)$ we have that

$$\frac{m(x;\rho_2)}{m(x;\rho_1)} \geq 1 \iff \frac{\bar{G}_N(x)}{\bar{G}_M(x)} \geq \frac{R^W_D}{R^W_M(\rho_2)} \frac{R^F(\rho_1)}{R^F(\rho_2) - R^F(\rho_1)}. \tag{7}$$

Holding the supply of firms constant ($R^F(\rho_2) = R^F(\rho_1)$), the native workers in the one-country model have to compete for the same jobs not only with each other, but also with immigrant workers. As a consequence, all the natives earn lower wages and firms receive higher profits. When we allow for adjustments in the number of firms, positive expected profits prompt the entry of new firms. While this increase in the supply of firms improves the matches of all workers in comparison to the case of constant firm supply, it cannot improve the matches of all workers in comparison to the no-migration benchmark, as this would result in negative expected profits. Thus, some native workers always match with more productive firms, whereas others end up in worse jobs. By inspection of Equation (7), the fact that the population of immigrant workers is less skilled than the population of native workers (in the sense of the hazard rate order) ensures that there exists some cutoff level $\hat{x} < \bar{x}$ such that matches improve for workers more skilled than $\hat{x}$ and deteriorate otherwise.[16] Thus, wages increase for high- and fall for low-skilled workers.

Proposition 1 (ii) establishes what happens to the average welfare of native workers, if natives were originally more skilled than migrants ($G_N \geq_{hr} G(\rho_1)$), and the overall skill distribution worsens. In such a case, the average wage of natives must increase. The intuition for this result is straightforward once we realize that workers with similar skills are substitutes, while workers with dissimilar skills are complements. Suppose that the change in G is caused by the arrival of new migrants: as the new overall skill distributions is dominated by the old distribution, which itself is dominated by the native distribution, the newcomers are *on average* complements to the natives; hence, the average wage of native workers must increase.

Mexican Migration to the United States Proposition 1 can be directly applied to the case of Mexican migration to the United States, because the empirical distribution of wages among the U.S. citizens (nearly) dominates the distribution of wages among Mexican immigrants in the sense of the hazard rate order (see Figure 1).[17] As in our model wages are strictly increasing in skill, and the hazard rate order is preserved by increasing transformations (Theorem 1.B.2. in Shaked and Shanthikumar, 2007), these empirical skill distributions can only be rationalized by our model if the Mexican migrants' skill distribution is dominated by the skill distribution of U.S. citizens.

The immediate consequence of this observation is that, absent any redis-

[16] Note that $\hat{x} < \bar{x}$, as the fact that all workers with $x < \hat{x}$ are matched with worse firms means that firm $m(\hat{x})$ has better outside options than in the no-migration benchmark, and can thus demand a higher share of the revenue produced by the match.

[17] A hawk-eyed reader might notice that the ratio of survival functions is very slightly decreasing for wages between 151,300 USD and 156,000 USD. While this means that hazard rate order dominance is not technically met, one would need a very particular revenue function for the conclusions of Proposition 1 not to hold.

tributive taxation, the presence of Mexican migrants in the United States increases the average welfare of U.S. citizens, but at the cost of an increase in wage inequality. However, because Proposition 1 applies to situations where there is some migration before the change in skill distribution (because it allows for $G_N \neq G(\rho_1)$), we can also explore the welfare and inequality consequences of counterfactual migration policies. The change in the ratio of the survival functions in the overall skill distribution in the United States in response to a change in Mexican migration can be decomposed as follows:

$$\ln\left(\frac{\bar{G}(\rho_2)}{\bar{G}(\rho_1)}\right) = \underbrace{\ln\left(1 + (\alpha(\rho_2) - \alpha(\rho_1))\left(\frac{\bar{G}_M(\rho_1)}{\bar{G}(\rho_1)} - \frac{\bar{G}_N}{\bar{G}(\rho_1)}\right)\right)}_{\text{share effect}}$$
$$+ \underbrace{\ln\left(1 + \frac{\alpha(\rho_2)\left(\frac{\bar{G}_M(\rho_2)}{\bar{G}_M(\rho_1)} - 1\right)}{\alpha(\rho_2) + (1 - \alpha(\rho_2))\frac{\bar{G}_N}{\bar{G}_M(\rho_1)}}\right)}_{\text{composition effect}},$$

where $G_N \geq_{hr} G(\rho_1) \geq_{hr} G_M(\rho_1)$, as shown in Figure 1.

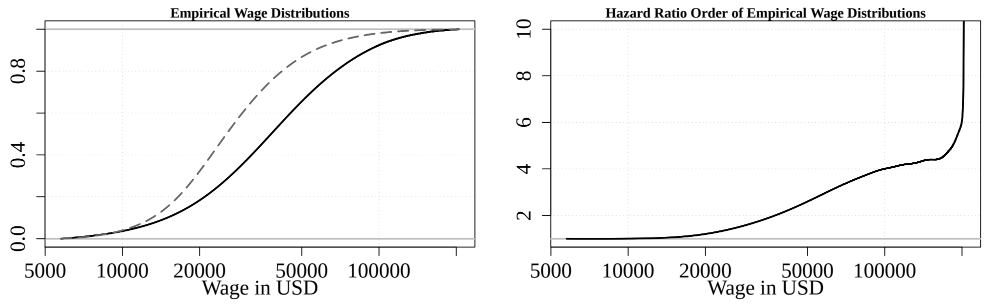


Figure 1: Wages of Mexican Immigrants Compared to U.S. Citizens

Note: The left panel of Figure 1 depicts the empirical wage distributions for U.S. citizens (solid black line) and Mexican migrants in the United States (dashed gray line). The right panel of Figure 1 plots the hazard ratio of U.S. citizens' over Mexican migrants' wage distributions.

The *share effect* captures the impact of a change in the number of migrants, but keeps their skill distribution constant. It follows immediately from Proposition 1 that the share effect of liberalizing the U.S. immigration policies would lead to an increase in the average wage of U.S. citizens, but at the cost of a further increase in U.S. wage inequality.

The *composition effect* of a change in migration policy, captures the impact of a change in migrants' skill distribution. Again, it follows from Proposition 1 that if the distribution of migrants' skill were to get worse in the hazard rate order sense, then both the average welfare and wage inequality would increase for U.S. citizens. It can be shown that improvements in migrants' skill distribution lead to opposite effects, as long as the changes in migrants' skill distribution are small (so that $\bar{G}_N \geq_{hr} \bar{G}_M(\rho_2)$).

However, the sign of the composition effect will depend both on the details of a specific migration policy, and on the existing selection patterns (the skill distribution among Mexican emigrants as compared to *Mexican stayers*). In the remainder of this paper, we develop a two-country, general equilibrium assignment model with endogenous migration choice, and calibrate it to the U.S.-Mexican data in order to evaluate the welfare and inequality consequences of modifying U.S. visa policy for Mexican immigrants.

3 Two-Country Model

The two-country model extends the previous one-country setting to a system of a sending (Mexico) economy and a destination (the United States) economy. Mexicans are mobile and make the decision about which country to work in by maximizing their real wages net of migration costs. U.S. citizens can only work in the United States.[18] Firms first choose whether to enter the market, then set the prices of the goods variety they produce, and decide which worker to employ. The goods produced by each company are traded with the other country and the rest of the world (ROW).[19]

[18] As indicated in footnote 1, the designation "U.S. citizens" includes also immigrants from other countries than Mexico—we treat migration from such countries as exogenous. According to the OECD's Database on Immigration in OECD and Non-OECD Countries (DIOC), only 90,000 of working-age U.S. citizens resided in Mexico in 2015, which sums up to 0.06 percent of the U.S. population active in the labor market.

[19] Only the Mexican and the U.S. economy are modeled explicitly. The prices of the goods traded by the ROW are given exogenously and their production is not modeled: the ROW is only included in the model to allow for a trade imbalance between Mexico and the United States

3.1 Workers and Firms

Workers There is a unit measure of Mexican citizens, each endowed with a vector of skills $(x_U, x_M) \in [0,1] \times [0,1]$. The skill x_U determines the worker's productivity in the U.S. labor market and the skill x_M determines her productivity in Mexico.[20] The joint distribution of X_U, X_M—conditional on the workers being Mexican citizens, denoted by C—has full support on $[0,1]^2$, and is twice continuously differentiable. Without loss of generality, we assume that the marginal distributions of X_U and X_M in the population of Mexican citizens are a standard uniform distribution.[21] This means that C is a copula (Sklar, 1959).

There is also a measure $R_U^W > 0$ of U.S. citizens. Assuming that these individuals cannot move to Mexico, each of them is fully described by her U.S. skill $x_U \in [0,1]$. The distribution of X_U among U.S. citizens, denoted by F, is twice continuously differentiable and has full support.

Firms In the two-country setup firms are modeled as in the one-country setup: firms first decide whether to pay the entry cost of $c_i^e > 0$ of the composite consumption good (defined in Section 3.2) to enter the market in country $i \in \{U, M\}$, then decide whether to remain active, or to exit the market. Active firms incur a fixed production cost of $c_i^f > 0$ units, and the set of active firms in country i is denoted by $\mathscr{H}_i \subset [0,1]$. If a country i-based firm of type h_i hires a worker with country i-specific skill x_i, they produce $f_i(x_i, h_i) = u_i(x_i)v_i(h_i)$ units of a firm-specific variety of the consumption good. We assume that $\partial u_i/\partial x_i, \partial v_i/\partial h_i$ exist and are strictly positive and continuous, and that $f_i(0, h_i) < 0$. Under these assumptions our model is equivalent to a model in which skills are u_i^{-1} distributed, firm productivity is v_i^{-1} distributed, and the output of any match is equal to the product of the worker's skill and the firm's productivity.

[20] It is best to think of the country specific skills x_U, x_M as indexes of basic skill sets (cognitive, manual, social, language). As the industrial structure of each country differs, firms require these basic skills in different proportions, giving rise to two sector-specific indexes x_U, x_M. In this sense x_U, x_M are akin to the tasks in Heckman and Sedlacek (1985). Section 2 in Gola (2019) provides the formal assumptions that are sufficient for such an aggregation of skills into two indexes without loss of generality.

[21] As shown in Section 2 of Gola (2019) the assumption of uniform marginal distributions is simply a normalization: We define the type of a Mexican worker in terms of the quantile she occupies in the distribution of each skill.

In line with Melitz (2003), each firm produces a unique variety of the consumption good, which implies that the measure of all varieties produced in a country is equal to the measure of all active firms in that market.[22] Because varieties are imperfect substitutes and firms know consumers' demand functions, the goods market is monopolistically competitive.

3.2 Goods Market

Welfare and Demand for Varieties People have homothetic preferences over the set of all available varieties (domestic and imported). Let ε be the elasticity of substitution between any two varieties. We can thus define a composite consumption good Q by taking the individual varieties as inputs, with

$$Q \equiv \left[R_U^F \int_{\mathscr{H}_U} q_U(h_U)^{\frac{\varepsilon-1}{\varepsilon}} \,\mathrm{d}h_U + R_M^F \int_{\mathscr{H}_M} q_M(h_M)^{\frac{\varepsilon-1}{\varepsilon}} \,\mathrm{d}h_M + q_W^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad (8)$$

where $q_i(h_i)$ denotes the consumption of a variety produced in country $i \in \{U, M\}$ by firm h_i and q_W denotes the consumption of goods produced in the ROW.[23] The utility of employed workers depends positively on the consumption of Q, and negatively on migration costs. Specifically, the utility of a worker with skill x_i employed in country $i \in \{U, M\}$ and born in country $j \in \{U, M\}$ is

$$U_{ij}(x_i) \equiv \ln(Q_i(x_i) - \delta_{ij}) - \Delta_{ij}. \quad (9)$$

In Equation (9), Δ_{ij} represents the personal (utility) cost of migration from country j to country i and is measured in utils, whereas δ_{ij} represents the monetary cost of legal migration barriers and is measured in units of the numeriare (Q). Of course, $\delta_{ii} = \Delta_{ii} = 0$, so that remaining in one's country of birth is costless. Unemployed workers do not earn and hence

[22]Unlike in Melitz (2003), however, there is no fixed cost of export, so that all active firms export part of their production.

[23]Regarding the ROW economy, we assume that the total production is given exogenously, and that demand depends on prices in the same way as in Mexico and the United States. A simple microfoundation would have the ROW consisting of a single representative consumer, who produces a constant quantity q_W of a single variety, and has the same preferences as the Mexican and U.S. consumers.

cannot afford to buy Q. They do, however, receive reservation utility from leisure/home production, with an unemployed country j citizen's utility equal to $\bar{U}_j$.

A worker supplying skill x_i in country i earns a wage $w_i(x_i)$ and maximizes her consumption of Q subject to the budget constraint

$$\sum_{k\in\{U,M\}} R_k^F \int_{\mathscr{H}_k} \tau_{ik} p_k(h_k) q_k(h_k)\,\mathrm{d}h_k + p_W \tau_{iW} q_W = w_i(x_i), \tag{10}$$

where τ_{ik} denotes the iceberg trade cost of shipping a good from country k to country i, whereas $p_k(h_k)$ denotes the price of the variety produced by firm h_k in country k. The price of the ROW variety p_W is treated as exogenously given.[24] The standard solution of the individual utility maximization problem reveals that a worker with skill x_i who is employed in country i demands

$$q_{ij}(x_i, h_j) = (\tau_{ij} p_j(h_j))^{-\varepsilon} \cdot P_i^{\varepsilon-1} \cdot w_i(x_i) \tag{11}$$

units of a variety produced by firm h_j in country j, where:

$$P_i = \left[\sum_{k\in\{U,M\}} R_k^F \int_{\mathscr{H}_k} (\tau_{ik} p_k(h_k))^{1-\varepsilon}\, \mathrm{d}h_k + (\tau_{iW} p_W)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}. \tag{12}$$

Finally, recall that in order to enter the market and produce, firms need to acquire a fixed amount of the composite good. Their cost-minimization problem is dual to the workers' utility maximization problem. Therefore, in order to purchase the amount of Q needed to pay the entry costs, every firm in country i will demand $(\tau_{ij} p_j(h_j))^{-\varepsilon} P_i^{\varepsilon} c_i^e$ of the variety produced by firm h_j in country j. To cover the production cost, active firms will also demand $(\tau_{ij} p_j(h_j))^{-\varepsilon} P_i^{\varepsilon} c_i^f$ of said variety.

Firms' Pricing Decisions Aggregate demand for variety h_i equals

$$q_i^A(h_i) = p_i(h_i)^{-\varepsilon} \cdot \sum_{k\in\{U,M,W\}} Y_k \left(\tau_{ki}/P_k\right)^{1-\varepsilon} = (B_i P_i / p_i(h_i))^{\varepsilon}, \tag{13}$$

[24] This is, of course, just a normalization, as only relative prices matter.

where $B_i = \left(\sum_{k\in\{U,M,W\}} Y_k \left(\tau_{ki}/P_k\right)^{1-\varepsilon}\right)^{1/\varepsilon} / P_i$ and Y_k is the total expenditure in country k equal to the sum of all of consumers' and all of firms' spending on the composite good. This allows us to write the inverse demand function:

$$p_i(h_i) = B_i P_i q_i^A(h_i)^{-1/\varepsilon}. \tag{14}$$

In equilibrium, the demand for variety h_i, $q_i^A(h_i)$, must be equal to its supply, $f_i(x_i, h_i)$, implying that the revenue produced by a worker-firm match (x_i, h_i) is equal to:

$$r_i(x_i, h_i) \equiv p_i(h_i) f_i(x_i, h_i) - P_i c_i^f = P_i(B_i f_i(x_i, h_i)^{\frac{\varepsilon-1}{\varepsilon}} - c_i^f). \tag{15}$$

The price levels set by producers are equal to constant markups over marginal cost, as in Melitz (2003).[25]

3.3 Labor Market

Demand for Skills and Firm Entry The demand for skills and firm entry in each country are determined exactly as in the one-country model. The only difference is that the cost of entry is denominated in units of the composite good, and thus the zero profit condition is $\pi_i^E = P_i c_i^e$.

Supply of Skills As in the one-country model, all workers decide whether to work or remain unemployed; additionally, Mexican citizens choose their country of residence. In reaching their decisions, workers take the nominal wage functions $w_i : [0,1] \to \mathbb{R}$ and the price indexes P_i as given.

*The cumulative supply of skill x_i provided by country j citizens in country i—$S_{ij}(x_i)$—*is defined as the measure of country j citizens employed in country i whose country-i specific skill is higher than x_i. It follows that:

$$S_{ij}(x_i) \equiv \Pr\left[X_i \geq x_i, U_{ij}(X_i) \geq \max\{U_{kj}(X_k), \bar{U}_j\}\right], \tag{16}$$

where $k \neq i$ and $U_{ij}(x_i) = \ln(w_i(x_i)/P_i - \delta_{ij}) - \Delta_{ij}$ by Equations (8), (9), (11) and (12). Since we assume that the total cost of moving from

[25] It follows from Equations (5) and (15) that: $\frac{\partial}{\partial x_i} w(\mu_i(h_x)) = \frac{\partial}{\partial x_i}\pi_i(\mu_i(h_i), h_i) = \frac{\partial}{\partial x_i} f_i(x_i(h_i), h_i) p(h_i) \frac{\varepsilon-1}{\varepsilon}$, $p(h_i) = \frac{\varepsilon-1}{\varepsilon} \frac{w'(x_i(h_x))}{\frac{\partial}{\partial x_i} f_i(x_i(h_i), h_i)} = \frac{\varepsilon-1}{\varepsilon} MC(h_i)$.

the United States to Mexico is prohibitive, only Mexican citizens reside in Mexico, and thus $S_{MU}(x_M) = 0$ for all x_M. Note that $S_{ij}(0)$ gives the measure of all country j citizens employed in country i.

Finally, *the cumulative supply of skill x in country i—$S_i(x_i)$—*is defined as the measure of workers of either origin living in country i with a skill level greater than x_i, so that

$$S_i(x_i) = S_{iU}(x_i) + S_{iM}(x_i). \tag{17}$$

Partial Labor Market Equilibrium Taking the revenue functions and price indexes as given, we can define the partial labor market equilibrium.

Definition 2. For a given pair of revenue functions r_U, r_M and price indexes P_U, P_M the *partial labor market equilibrium* is characterized by

1. the demand for skills $D_i : [0, 1] \to [0, 1]$ in each country, which is determined by firms' profit maximization, given by Equation (2);

2. the supply of skills $S_i : [0, 1] \to [0, 1]$ in each country, which is determined by workers' sorting decisions, given by Equations (16)–(17);

3. firms' measures R_i^F, consistent with the zero-expected-profits-condition, such that $\pi_i^E = P_i c_i^e$ if $R_i^F > 0$ and $\pi_i^E \leq P_i c_i^e$ otherwise;

4. wages $w_i : [0, 1] \to \mathbb{R}$ in each country, which are set to clear the markets: $S_i(x_i) = D_i(x_i)$ for $i \in \{U, M\}$ and all $x_i \in [0, 1]$.

Theorem 1. The equilibrium defined in Definition 2 exists and is unique.

We provide a sketch of proof here, a detailed proof can be found in Online Appendix A. Note that for an allocation $A = (S_{UU}, S_{UM}, S_{MM}, R_U^F, R_M^F)$, the wage functions are derived analogously to the one-country model. Thus, the only major difference lies in the fact that the supply of workers in each country depends on the endogenous sorting of Mexican workers between Mexican and U.S. labor markets. To operationalize this endogeneity, we first define the critical skill $x_{ij}^c = \sup\{x_i \in [0, 1] : S_{ij}(x_i) = S_{ij}(0)\}$; that is, the lower bound of the set of skill levels possessed by active workers born in country j and working in country i. This allows us to define the separation function $\psi : [x^c_{UM}, 1] \to [x^c_{MM}, 1]$

$$\psi(x_M) = \max\{x_U : e^{-\Delta_{UM}} \left(\bar{w}_U(x_U) - \delta_{UM}\right) \leq \bar{w}_M(x_M)\}, \qquad (18)$$

where $\bar{w}_i(x_i) \equiv w_i(x_i)/P_i$ denotes the *real wage* defined in terms of units of Q. The separation function characterizes the set of Mexicans indifferent between emigrating and staying.[26] Consequently, for any $x_i \geq x^c_{iM}$, the supply functions of migrants in the United States and stayers in Mexico are, respectively, equal to:

$$S_{UM}(x_U) = \int_{x_U}^{1} \frac{\partial C(r, \phi(r))}{\partial x_U}\,\mathrm{d}r, \quad S_{MM}(x_M) = \int_{x_M}^{1} \frac{\partial C(\psi(r), r)}{\partial x_M}\,\mathrm{d}r, \quad (19)$$

where $\phi(x_U) \equiv \sup\{x_M \in [x^c_{MM}, 1] : \psi(x_M) < x_U\}$. It follows that

$$S_{UM}(\psi(x_M)) + S_{MM}(x_M) = 1 - C(\psi(x_M), x_M), \qquad \text{for } x_M \geq x^c_{MM}. \quad (20)$$

Finally, the supply of U.S. citizens' skills equals

$$S_{UU}(x_U) = R^W_U(1 - F(x_U)), \qquad x_U \geq x^c_{UU}. \qquad (21)$$

We then use the fact that any allocation that constitutes a partial equilibrium must satisfy Equations (19)–(21) and labor market clearing, in order to restrict the set of all allocations to a set of *feasible* allocations $\mathbb{A}$. Subsequently, we show that an allocation can constitute a partial equilibrium if and only if it uniquely maximizes (among all feasible allocations) the weighted sum of net revenues generated in the two-country economy:

$$\begin{aligned} V(A) \equiv e^{-\Delta_{UM}} &\left[T_U(A) + \bar{w}^c_U F(x^c_{UU}) R^W_U - R^F_U c^e_U\right] \\ &+ T_M(A) + \bar{w}^c_M C(x^c_{UM}, x^c_{MM}) - R^F_M c^e_M - \delta_{UM} S_{UM}(0), \end{aligned} \qquad (22)$$

where $T_i(A) \equiv P_i^{-1} \int_1^0 r_i\Big(x_i, 1 - S_i(x_i)/R^F_i\Big)\,\mathrm{d}S_i(x_i)$ is the total revenue produced in i. This result immediately proves the partial equilibrium's uniqueness and allows us to prove its existence by a straightforward appli-

[26] Clearly, Mexicans with $x_U > \psi(x_M)$ emigrate, while the rest stay in Mexico.

cation of the Weierstrass Theorem.

3.4 General Equilibrium

The economy is in general equilibrium if the goods market is in equilibrium given the total expenditures resulting from the labor market, and the labor market is in equilibrium given the revenue functions and price indexes resulting from the goods market. The following condition, which must hold in equilibrium for any $i \in \{U, M, W\}$ by Equations (12), (13), (15), and (24), provides the link between the goods and labor markets:

$$P_i = \left[\tau_{iU}^{1-\varepsilon} Y_U \left(B_U P_U\right)^{-\varepsilon} + \tau_{iM}^{1-\varepsilon} Y_M \left(B_M P_M\right)^{-\varepsilon} + \left(\tau_{iW} p_W\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}, \tag{23}$$

where

$$\begin{aligned} Y_i &= P_i(S_i(0)c_i^f + R_i^F c_i^e) + \int_1^{x_i^c} w_i(x_i)\,\mathrm{d}S_i(x_i) \\ &= \int_1^{x_i^c} r(x_i, 1 - S_i(x_i)/R_i^F) + P_i c_i^f\,\mathrm{d}S_i(x_i). \end{aligned} \tag{24}$$

Definition 3. The economy is in general equilibrium if the revenue functions (r_U, r_M), price indexes (P_U, P_M, P_W), and total expenditures (Y_U, Y_M) are such that:

(i) the total expenditures are consistent with the partial equilibrium of the labor market given the revenue functions and price indexes (Definition 2 and Equation (24));

(ii) price indexes are consistent with individual preferences, consumers' utility maximization problem and goods market clearing, given the total expenditures (Equation (23));

(iii) the revenue functions are consistent with market clearing conditions in the goods market, given the total expenditures (Equation (15)).[27]

The general equilibrium exists, but is not necessarily unique.

[27] In addition to these three requirements, Equation (13) must hold for the ROW as well; that is, the market for q_W must clear. However, Walras' Law ensures that if all other markets clear, the market for q_W does too, and thus the above definition of equilibrium is sufficient.

Theorem 2. The general equilibrium exists. It is unique if trade is costless ($\tau_{ij} = 1$ for all $i, j \in \{U, M, W\}$).

If trade is costless, then $P_U = P_M = P_W$ and $B_U = B_M = B_W$ irrespective of Y_U, Y_M, and the uniqueness follows directly from the uniqueness of the labor market equilibrium (Theorem 1).[28] If trade costs are greater than 1, the equilibrium might not be unique. As pointed out by Krugman (1980), if trade is costly, then *ceteris paribus* real wages are higher in the larger country than in the smaller country, as the larger country has cheaper access to a greater range of varieties. This creates a force for any general equilibrium condition characterized by very high emigration from Mexico to become self-enforcing. In particular, as trade costs become prohibitively high, a complete out-migration of all employed Mexican citizens must constitute an equilibrium.[29]

It is worth pointing out that, while unfortunate, the multiplicity of equilibria does not pose a big problem for our calibration exercise. There are two reasons for this. First, the equilibrium of our calibrated model turns out to be unique, which is likely caused by the large volume of trade between Mexico and the United States, as well as between Mexico and the ROW (see Figure C.4 in Online Appendix C). Second, even if there were multiple equilibria, our calibration procedure would select the one most closely resembling the data.

4 Calibration

This section contains a discussion of the numerical calibration of the model. After specifying and motivating our functional form assumptions (Section 4.1), we provide a description of the datasets used to calibrate the model (Section 4.2) and comment on the results of the benchmark calibration (Section 4.3).

[28]To see this, note that $B_W = p_W q_W$ in equilibrium.

[29]See Online Appendix A for a proof.

4.1 Functional Forms

Copula In our quantitative exercise, we allow for a positive dependence between the skills used by Mexicans in each country.[30] However, the strength of this relationship can vary across quantiles. For this reason, we select the Clayton copula, which imposes strong (weak) correlation between low (high) quantiles.[31] The distribution of this copula follows Equation (25) and is characterized by a parameter θ, that determines the rank correlation between quantiles of marginal distributions. In particular, Kendall's τ is equal to $\theta/(\theta+2)$.

$$C(x_U, x_M) = \left(x_U^{-\theta} + x_M^{-\theta} - 1\right)^{-1/\theta}, \quad \theta > 0. \tag{25}$$

Production Functions We assume that skills are log-normally distributed and productivity is Pareto distributed, or, equivalently, that $u_i(x_i) = \exp\left(\Phi_i^{-1}(x_i; k_i, s_i)\right)$ and $v_i(h_i) = (1-h_i)^{-1/\gamma_i}$, where Φ_i denotes the cumulative distribution function (CDF) of the normal distribution with location k_i and dispersion s_i.[32]

Wage distributions resemble a log-normal distribution, but are positively skewed. Given that the skewness of the wage distribution will be produced in our model by selection and positive assortative matching, using

[30] Assuming a negative correlation between skill levels would imply that Mexicans who are highly ranked in the Mexican skill distribution would be characterized by a relatively low level in the U.S. skill rankings, and vice versa. We consider this case less probable than the positive relationship, since the process of accumulating skills in each country requires a similar set of individual traits (an ability to learn, adapt, and develop manual capabilities or educational proficiency in a particular environment).

[31] Consider a Mexican medical doctor who works in Mexico and is ranked very high in the Mexican wage distribution. Had she chosen to migrate to the United States, she might have encountered significant difficulties in having her diploma recognized. Thus, she might have decided to take a job of a nurse, which does not fully exploit her abilities and significantly reduces her ranking within Mexican immigrants in the United States. Conversely, a construction worker in Mexico who is located in the left tail of the wage distribution presumably has little chance to achieve a better ranking after migrating to the United States (by accepting a relatively low U.S. wage). However, Mexican workers with skills that are easily transferable across borders (e.g. trained construction workers such as crane operators) could probably overtake a significant number of their compatriots in the U.S. wage ranking, as they do not need to acquire and be recognized as having U.S.-specific skills to make a full use of their abilities.

[32] Both of these distributions are assumed to be truncated at three-sigmas. Formally, our existence proofs require Lipschitz continuity, which means that there needs to be a limit on the support of the distributions.

a log-normal appears to be the most natural choice for the skill distribution.[33] With regards to firms' productivity, our choice of the distribution is motivated by the extensive body of literature which advocates that various characteristics of firms follow a Pareto distribution (see Axtell, 2001; di Giovanni et al., 2011).[34]

Separation Function We assume that for each level of U.S. skill there exists a Mexican who stays in Mexico and a Mexican who migrates to the United States.[35] This removes one degree of freedom, as it implies that $\psi(1) = 1$, and thus pins down the initial point for solving the differential equation that determines the separation function.

4.2 Data Description

The calibration represents a static state of the Mexican and U.S. economies in 2015. We differentiate between two types of empirical moments that we use to calibrate the model. First, we collect a set of observables that exogenously determine some model parameters. Second, we construct empirical moments that directly correspond to the moments generated by the model and, thus, enable us to identify the remaining model parameters.

Below we briefly describe the data used for the calibration. Table C.1 in the Online Appendix summarizes the values of all moments collected from several sources of data. The demographic characteristics of both countries originate from the Database on Immigrants in OECD and non-OECD

[33]As shown first by Heckman (1979), the empirical distribution of wages deviates from a log-normal distribution largely due to workers' selection into the labor market. A micro-founded derivation of a skew-normal distribution that naturally follows from workers' sorting decisions, as in Roy (1951) and Borjas (1987), can be found in Azzalini and Valle (1996) and Azzalini (2005). Positive and assortative matching boosts wage inequality and significantly increases the third moment of the wage distribution in relation to the marginal skill distributions (see, e.g. Sattinger, 1975). Finally, the log-normal distribution of marginal skills can be theoretically justified, as the product of many independently distributed random variables (Roy, 1950). Thus, if one believes that the aggregate workers' skill level is the product of many independent characteristics, it follows that it is log-normally distributed.

[34]Note that setting parameter $\gamma_i \to \infty$ imposes both no matching and a degenerated distribution of firms' productivity, which brings our framework back to the general selection model by Roy (1951), which has exogenously given log-normal distributions of wages. Shutting down matching precludes the analysis of firm entry and exit.

[35]This must be true in the untruncated version of the model.

Countries (DIOC). This source reports that there are 54.4 million Mexicans aged 15-64 (employed and unemployed natives and migrants), 44.9 million of whom are employed in Mexico, and 7.5 million who are (legally) employed in the United States. 155 million people are aged 15-64 in the US (natives and non-Mexican immigrants), 146 million of whom are actually employed.

In each country, we divide the gross domestic product (GDP) into three broad categories: wage shares, corporate profit shares, and the consumption of fixed capital (capital investment shares). The first element must match the sum of remunerations, the second element pins down the share of firms' operating profits, whereas the third element determines the investment costs that cover the depreciation of fixed capital.[36]

With regards to labor markets, the unemployment rate in Mexico equals $u_M = 3.45$ percent, whereas in the United States it reaches $u_U = 5.75$ percent, following the DIOC. We determine wage distributions for the three groups of individuals under analysis: workers in the United States, Mexican stayers, and Mexican migrants to the United States. We calibrate the model on intercensal data from Mexico and the United States. We use the 2015 and 2016 one percent American Community Survey (ACS) data provided by IPUMS, Ruggles et al. (2017), and we compute yearly wage data for 2.75 million U.S. workers and 107,000 Mexican immigrants living in the United States.[37] For Mexico, we use the Mexican 2015 intercensal survey provided by IPUMS International, from which we extract the last month's earnings in Mexican pesos for 3 million Mexicans. To make the Mexican wage units comparable with those obtained for the United States, we convert peso values into yearly wages in 2015 purchasing power parity (PPP) adjusted

[36]Capital investments are the non-labor costs incurred by firms in the production process. Using the FRED classification of capital expenditures into "equipment," "intellectual property," and "structures," we categorize non-labor costs into their variable and fixed parts. The first two groups compose the variable part, while investment in "structures" is assumed to constitute the fixed portion of production costs. With the above data on the structure of GDP in Mexico and the United States, we can compute the fixed cost of production, c_i^f.

[37]In the ACS, wages are reported as "Wages or salary income last year" and are quoted in USD. Thus, the 2015 ACS contains wage data both from 2015 and from 2014, if a respondent was interviewed in January 2015. We correct this bias by adding the ACS 2016 sample. We correct for heterogeneity in hours and weeks worked by computing 40-hour-per-week, 52-week per year equivalents.

USD.

Furthermore, we supply the model with international trade data. The actual trade flows across the United States, Mexico and the ROW are determined by "Gross exports by final destination and origin of value added", obtained from the OECD's Trade in Value–Added database. The full trade matrix for the United States, Mexico and the ROW enables us to fit bilateral trade costs, τ_{ij}, assuming $\forall i \; \tau_{ii} = 1$.

Finally, we need additional moments to pin down the two-dimensional skill distributions in the Mexican population, represented by the Clayton copula. To this end, we compute conditional probabilities of migration for Mexicans (the probability of being classified in a particular quantile of the Mexican wage distribution conditional on migrating). We exploit the data provided by the Mexican Migration Project (MMP), which collects the wages of Mexican immigrants to the United States. Focusing on wages before moving, we compute their frequency within quantiles of Mexican stayers' wage distributions. These probabilities, which formally take the form of $\partial C(\psi(G_M^{-1}(x)), G_M^{-1}(x))/\partial x_M$, reflect migrants' self-selection. We obtain a result that is very much in line with the findings of Moraga (2011) and Kaestner and Malamud (2014). In these papers, the probability that a Mexican emigrates to the United States is negatively related to her wage quantile in Mexico.

4.3 Identification of the Reference Calibration

The identification strategy relies on the functional forms imposed in Section 4.1 and the datasets described in Section 4.2.[38] This subsection provides a general discussion of the identification strategy. Online Appendix C offers a detailed description of the calibration algorithm and identification, a graphical analysis of the chosen parameter vector, and a backward recalibration of the model to the 2010 data.

The calibration algorithm has a simple conceptual design. First, given observables gathered in group (A) in Table C.1, we set the values of some

[38] Our model is only parametrically identified, similarly to self-selection models analyzed by Heckman (1979), Heckman and Sedlacek (1985), Heckman and Honoré (1990), and Borjas (1987). It is impossible to identify non-parametrically a selection model using a single cross-section (Heckman and Honoré, 1990).

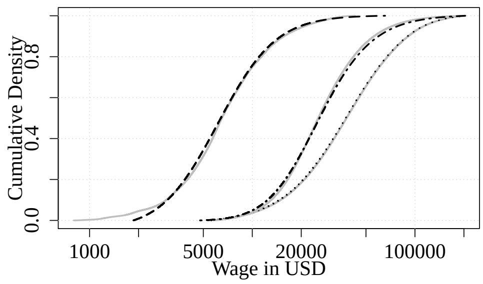
model variables. Second, after normalizing Mexican marginal skill distributions to uniform (without loss of generality), we compute the skill distribution of U.S. citizens F, as a residual from Equation (5). This is done for a given empirical distribution of U.S. wages, and a guess for model parameters $\Xi = \{k_U, s_U, \gamma_U, k_M, s_M, \gamma_M, \theta, \Delta_{UM}, \delta_{UM}\}$. Third, we find which guesses of model parameters Ξ minimize the loss function (C.4).[39] The loss function summarizes the distance between empirical moments from group (B) in Table C.1 and the respective values generated by the model. Our model is necessarily over-identified as having only nine parameters we match five discrete empirical moments, a set of conditional emigration probabilities from Mexico and two distributions.[40] In particular, if the value of the loss function is zero, then the vector Ξ would need to solve the system of nine equations (C.I1)–(C.I9).

The calibrated vector of parameters generates three model wage distributions that replicate the actual data well. Figure 2a displays the empirical distributions in gray and the model distributions in black (long-dashed for Mexicans in Mexico, double-dashed for Mexicans in the United States, and dotted for U.S. citizens).

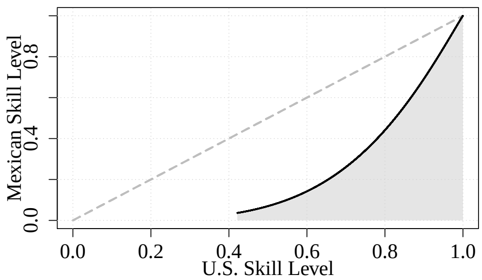
The selection pattern of Mexican immigrants to the United States generated by our calibrated model is depicted in Figure 2b, with the inverse separation function ϕ in solid black in the (x_U, x_M) space. The separation function indicates which quantiles of Mexican workers decide to migrate (depicted by the gray shaded surface to the right of the solid black line) and who stays in Mexico (to the left of the solid black line). Figures 2c and 2d depict Mexicans' selection patterns with respect to Mexican (U.S.)

[39] The search is done over a nine-dimensional parameter space using a Monte Carlo algorithm with a Simulated Annealing Optimization method.

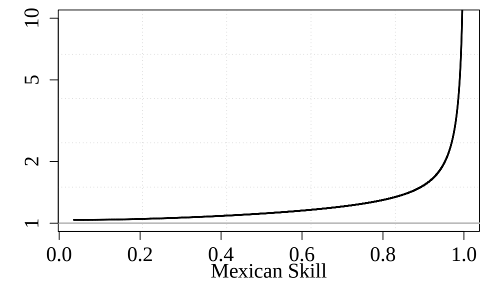
[40] Heckman and Honoré (1990) prove that a two-country, log-normal Roy (1951) model is exactly identified with three country-specific parameters that determine the location, dispersion, and skewness of wage distributions and the number of migrants. It stands to reason that Roy's model with log-normal marginals and the (one-parametric) Clayton copula is also identified exactly by these moments. Our model extends Roy (1951) through the inclusion of worker-firm matching, which enlarges the set of parameters by γ_i's to account for firms' non-degenerated profit distributions. Actually, the parameter γ_i is exactly the one that determines the "distance" between the classic Roy (1951) model and our model with matching. In this sense, we need at least nine moments in the data to identify the model. We provide more, as we fit numerous quantiles of wage distributions, which despite being characterized by strong cross-sectional correlations, generate at least three moments per country: location, dispersion, and skewness.



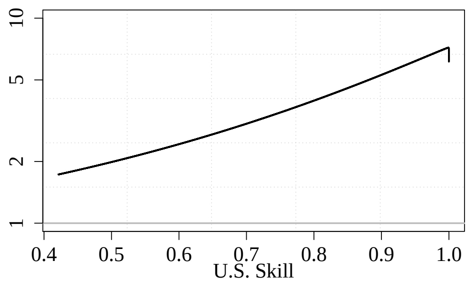
(a) Wage Distributions' Fit



(b) Separation Function



(c) Selection in Mexican Skills in HRO



(d) Selection in U.S. Skills in HRO

Figure 2: Model Calibration and Selection Patterns

Note: Figure 2a compares the calibrated wage distributions to the counterparts in the data. The black long-dashed line represents the model wage distribution in Mexico, the black double-dashed line represents the Mexican immigrants' wage distribution in the United States, and the black dotted line represents U.S. citizens' wage distribution. The gray lines depict respective empirical distributions. The horizontal axis is in PPP adjusted USD on log scale. Figure 2b plots the separation function (in solid black) compared to the 45-degree line (dashed gray) in the space of Mexicans' skill levels (x_U, x_M). Figure 2c illustrates the ratio of the survival functions of Mexican-specific skills for employed Mexican stayers' over all Mexicans. Figure 2d depicts the ratio of the survival functions of U.S.-specific skills for Mexican emigrants over all Mexicans. HRO stands for hazard rate order.

skills as the ratio of survival functions of employed stayers (migrants) and the overall population. Figure 2d makes it clear that Mexican emigrants possess a significantly higher level of U.S. skills than Mexican stayers—Mexican migrants to the United States are *positively selected with regards to U.S. skills*. However, Figure 2c shows that Mexican stayers have higher Mexican skill levels than Mexican emigrants—Mexican migrants to the United States are *negatively selected in terms of Mexican skills*. The latter stays in line with recent empirical studies (Moraga, 2011; Kaestner and Malamud, 2014).

5 Main Results

This section provides a quantitative evaluation of the impact that Mexican immigration to the United States has on both economies, with a particular focus on welfare and earnings inequality. First, in Section 5.1 we assess the overall impact of Mexican migration on the wage distribution in the United States. Second, in Section 5.2 we simulate the economies under a range of different immigration policies and report the implications of these results for U.S. citizens. Finally, in Section 5.3 we analyze the effects of further policy changes.

Note that we will frequently refer to the following decomposition of the overall effect of migration and/or policy changes on real wages:

$$\ln\left(\frac{\bar{w}_i(x_i;\rho_2)}{\bar{w}_i(x_i;\rho_1)}\right) = \underbrace{\ln\left(\frac{\bar{w}_i(x_i;\rho_2,B_i(\rho_2))}{\bar{w}_i(x_i;\rho_1,B_i(\rho_2))}\right)}_{\text{labor market effect}} + \underbrace{\ln\left(\frac{\bar{w}_i(x_i;\rho_1,B_i(\rho_2))}{\bar{w}_i(x_i;\rho_1,B_i(\rho_1))}\right)}_{\text{market size effect}}. \quad (26)$$

The labor market effect captures the direct, partial equilibrium effect that migration has on the real wage, holding B_i constant for all i. The market size effect captures the impact that migration has on the real wage through the general equilibrium changes in price indexes and demand for goods in all countries.

5.1 The Economic Effects of Mexican Migration to the United States

The results presented in this subsection document the difference between the current situation (represented by our calibrated economy) and the counterfactual case, in which there is no Mexican migration to the United States (this case is modeled by setting migration costs to infinity). Thus, positive values represent gains from migration and negative values represent losses.

The economic effects of Mexican migration to the United States for U.S. citizens (solid black lines in Figures 3a and 3c) are in line with Proposition 1 (i): the low-earning U.S. citizens lose from migration, whereas the medium- and high-earners gain from Mexican migration. The magnitude of

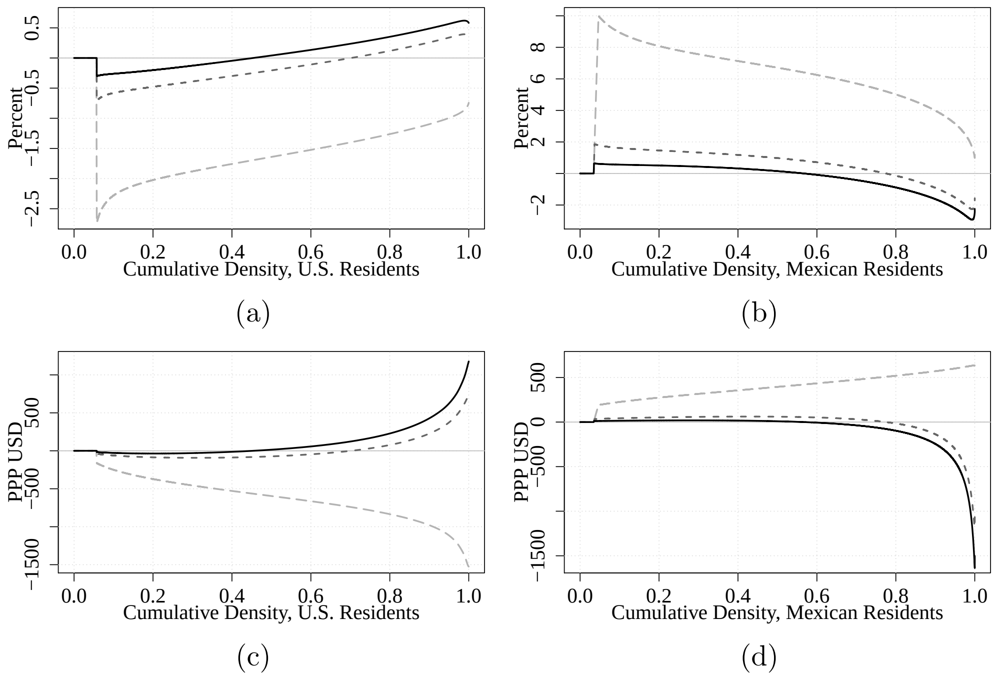


Figure 3: Welfare Effects of Mexican Immigration to the United States

Note: Figure 3 presents the economic effects of Mexican migration to the United States (the difference between the current situation and the no-migration counterfactual). Figure 3a (3b, respectively) contains the relative changes in U.S. citizens' (Mexican stayers') real wages along the distribution, while Figure 3c (3d) provides absolute variations in U.S. citizens' (Mexican stayers') real wages in PPP-adjusted USD. The solid black lines include all effects, the short-dashed gray lines represent just the labor market effects, while the long-dashed light gray lines prevent the entry and exit of firms. The horizontal axes represent quantiles of respective wage distributions.

these effects is, however, moderate: in the United States the changes in real wages range from –0.3 percent (roughly –20 USD of annual remuneration for the sixth lowest percentile of the U.S. wage distribution) to 0.6 percent (approximately 1,100 USD for the 99th percentile). The U.S. unemployment rate rises by only 0.01 basis points, whereas the average wage earned by U.S. citizens grows by 0.25 percent (approximately 120 USD). Finally, note that the labor market effect leaves the median U.S. citizen worse off from Mexican immigration. It is only due to the market size effect that the majority of U.S. citizens gains from migration: the higher supply of workers in the United States prompts firm entry, which then enriches the set of domestically produced varieties and increases the real wages (net of the reservation wage) by the same proportion for all workers.

The effect that the emigration of Mexican workers has on Mexican stayers is a mirror image of the impact that this migration has on the U.S. citizens: the low-earning workers gain, whereas the high-earning workers lose. This is because the calibrated Mexican skill distribution among the stayers is better (in the hazard rate order sense) than in the entire Mexican population (see Figure 2c). The gains for low earning Mexican stayers are very low in magnitude: 0.6 percent (10 USD in the fourth lowest percentile of the Mexican wage distribution). The highest-skilled Mexicans lose up to –2.9 percent of their real wage (amounting to around –1,500 USD). Unemployment decreases by 0.24 percentage points.

Mexican migration to the United States turns out to act as a substitute for trade in our calibrated economy. As a result of Mexican migration to the United States the trade flow from the United States to Mexico drops by 4.8 percent, while the reciprocal flow decreases by almost 5 percent (Table 1). Pointedly, after examining the nominal values of trade flows, the presence of Mexicans in the United States improves the U.S. trade balance vis-à-vis Mexico by 6 percent.

Table 1: Changes in Bilateral Trade Flows due to Mexican Migration

To:\From:	ROW	MEX	US
ROW	–0.11%	–6.90%	1.92%
MEX	–6.66%	–13.01%	–4.77%
US	2.01%	–4.93%	4.07%

5.2 Changes to Migration Policy

In this section we evaluate the impact of U.S. migration policies that change the monetary cost of migration (δ_{UM}). We consider a range of policy interventions that modify the cost of entering the United States for all Mexicans. First, we assume that the migration cost is "burned" and thus constitutes a burden on the global economy. Second, we consider scenarios in which (a) an increase in the migration cost is caused by a tax on immigration or an increase in visa costs, the revenues from which are the redistributed among U.S. citizens; and (b) a fall in the migration cost is complemented by greater redistribution from high- to low-earning U.S. citizens.

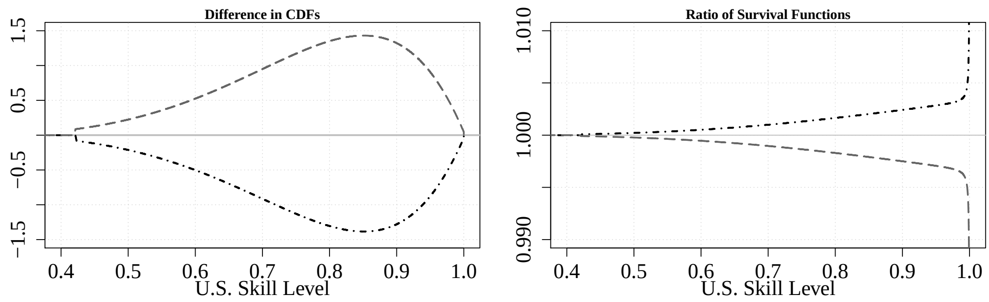


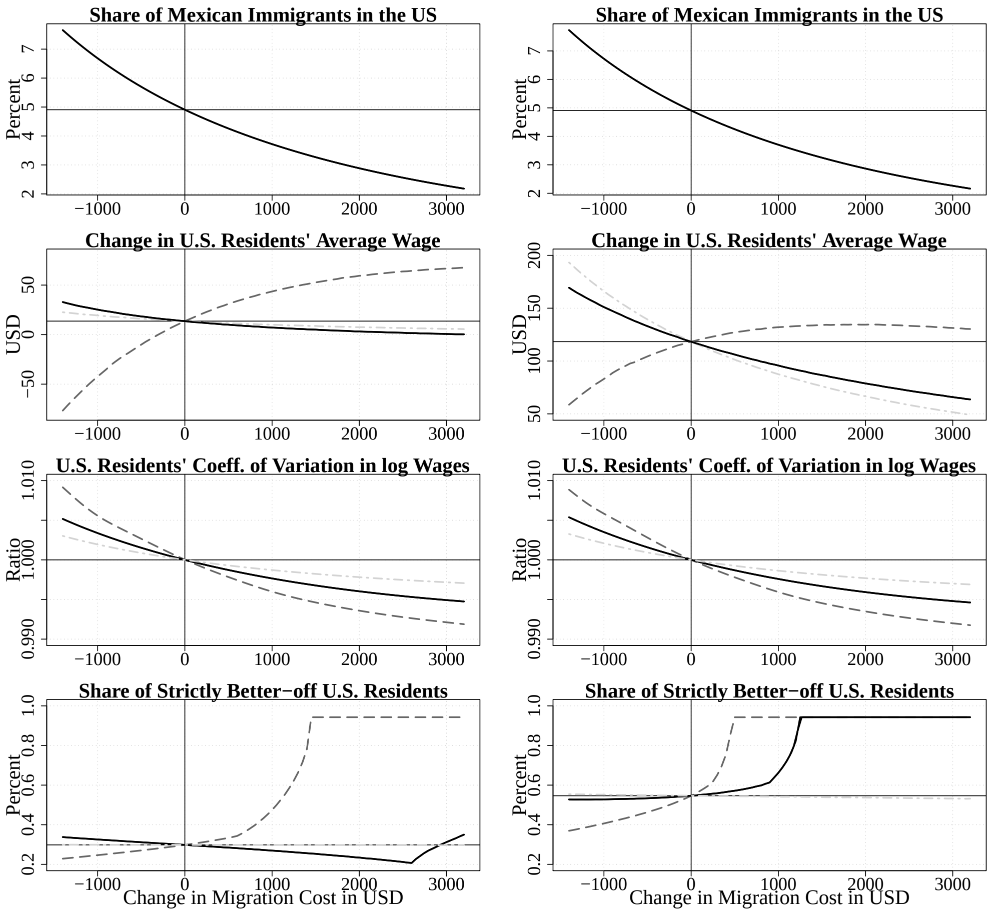
Figure 4: Changes in Mexicans' Skills for Small Differences in Migration Costs

Note: Figure 4 presents the changes in Mexican immigrants' CDFs of U.S.-specific skill levels after small changes in visa costs. The black double-dashed lines (gray long- dashed lines, respectively) consider the case of increasing (decreasing) visa costs by 10 USD. The left panel depicts differences in CDFs (counterfactual less reference), while the right panel considers relative changes in survival ratios (counterfactual over the reference).

Let us start with the labor market effect of a decrease in δ_{UM}, the monetary cost of migration. As discussed in Section 2, the overall effect of a decrease in δ_{UM} on the wages of U.S. citizens can be decomposed into the share and composition effects. Since qualitatively the share effect is fully determined by the empirical relationship between the wage distributions of migrants and natives, the overall result hinges on the composition effect. Figure 4 depicts the composition effect of small increases and decreases in migration cost: the differences in CDFs are plotted in the left panel, and the ratios of survival functions in the right panel. The changes in Mexican migrants' skill distribution are monotone in both cases: lower (higher) migration costs worsen (improve) the skill distribution of Mexican workers in the United States. The standard intuition from Heckman and Honoré (1990) applies here: the fall in δ_{UM} draws migrants whose comparative advantage was in the Mexican skill at the old migration cost. Accordingly, the labor market effect of a fall in δ_{UM} benefits high-earning U.S. citizens more than it hurts low-earning ones, thus increasing both the average and the variance of U.S. citizens' wages. This is depicted in Figure 5a.[41]

As explained in Section 5.1, the market size effect of an increase in the number of migrants increases real wages (net of the reservation wage) by

[41] The behavior of the average wage in this graph is substantially different than in the previous version of this paper (Burzyński and Gola, 2019): the reason is a coding error in the old version.



(a) (b)

Figure 5: Aggregated Effects of Migration Policies in the United States

Note: Figure 5 presents aggregated measures of U.S. citizens' welfare after implementing alternative costs for Mexican immigrants, relative to the no-migration scenario. The first row depicts changes in the share of Mexican immigrants in the United States in percent; the second row illustrates the changes in average wages of U.S. citizens in USD; the third row considers changes in the variance of log wages; while the fourth row shows the fraction of U.S. citizens who are strictly better off in percent. Panel (a) summarizes the results with the labor market effect only, while panel (b) considers also market size effects. Black solid lines represent the case of "burned" migration costs, the light gray double-dashed lines close down the selection of migrants (with the share effect being active), while the gray long-dashed lines denote the case of redistributing additional visa costs as transfers for U.S. citizens. Horizontal axes present deviations in monetary costs of migration, δ_{UM}, relative to the *status quo*.

the same proportion for all workers, further increasing both average wages and the variance of log wages.[42] Thus, a decrease in δ_{UM}, the pecuniary cost

[42] The only difference is that the worsening of migrants' skill distribution means that the increase in the number of workers in the United States has less of a positive effect on

of migration, increases both the average and the variance of the natives' wages in general equilibrium as well, as depicted in Figure 5b.

Our quantitative analysis very much confirms that a tension exists between the efficiency and equality motives of migration policy. A natural way of resolving this tension is to complement changes in a nation's migration policy with tax policy changes. As both high-skilled natives and the migrant workers benefit from migration, taxing either group should result in an overall increase in average welfare and a fall in inequality. In the remainder of this section we consider both possibilities.

First, consider a case in which the migration cost increases due to a tax on migration.[43] The proceeds from this tax are then redistributed among the U.S. citizens, with all U.S. citizens receiving the same lump-sum transfer. This case is depicted with long-dashed gray lines in Figure 5. The increase in the migration cost δ_{UM} decreases both the average wages and the log wage variance among U.S. citizens. However, the fall in the average wage received by U.S. citizens is more than compensated for by the lump- sum transfer. As shown Figure 5b, for moderate levels of taxation, the average wage received by natives (after transfers) increases: the maximum average wage is achieved for an annual tax of 2,000 USD levied on Mexican immigrants.

Second, consider a case in which the government introduces a linear tax on the earning of all U.S. citizens, the proceeds of which are then redistributed among the U.S. citizens through a lump-sum transfer. Such a tax has no effect on average wages (after tax and transfers), but lowers wage inequality. In particular, for any decrease in the cost of migration, δ_{UM}, there must exist a level of taxation that leaves the variance of natives' wages unchanged compared to the *status quo*.[44] Thus, there must exist such a combination of a decrease in δ_{UM} and an increase in the tax rate that increases the average wage of U.S. citizens and keeps the variance of their wages unchanged. Figure D.2 in the Online Appendix plots the tax rates

the number of U.S. firms, domestically produced varieties and hence also on real wages.

[43] To avoid any stigma connected to being a migrant, this tax could be charged up-front, or framed as an increase in the cost of a visa.

[44] In this exercise, we assume that the fall in δ_{UM} has no impact on government revenues; rather, it would, thus, need to be an overall decrease in the administrative effort required to issue a visa, rather than a decrease in the cost of obtaining a visa.

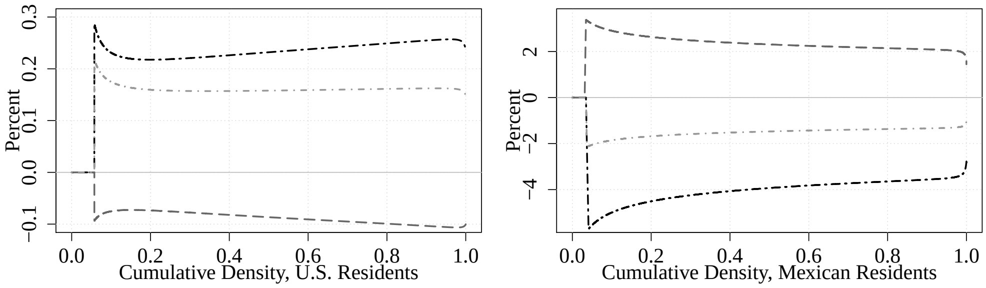
needed to achieve that policy goal as a function a decrease in δ_{UM}. For example, a fall in δ_{UM} by 1,000 USD requires a rise in the tax rate on U.S. citizens income of 0.25 percent (or 0.2 percent if the market size effect is internalized).

5.3 Further Policy Simulations

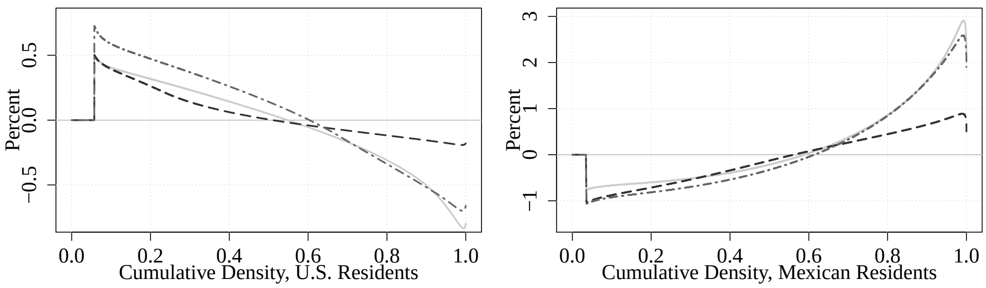
Trade Policy and Migration Recently, the U.S. administration proposed increasing tariffs on Mexican imports, a policy intended to force the Mexican government to financially participate in supporting border control between the United States and Mexico. The direct effect of such an action is calculated to reduce Mexican exports, which will depress Mexico's economy. However, if the policy were to fail in forcing the Mexican government to increase the cost of migrating to the United States, its effect on migration would be exactly opposite to the policy's intended consequences. Twenty percent higher tariffs on Mexican exports slightly increase real wages in the United States, but drive Mexican remunerations down (Figure 6a, double-dashed black line). This motivates more Mexicans to emigrate to the United States, and the new migrants are less skilled than the current migrants. Thus, the U.S. tariff policy is a credible threat to the prosperity of Mexican economy, but the policy acts against the principles of U.S. immigration policy towards Mexico declared by the U.S. administration. A hypothetical retaliation from Mexico (the long-dashed gray line), would result in significant gains for this country, with only slight impact on the wages of U.S. citizens. A trade war between the two countries (double-dashed light-gray line) would have a uniform impact on both wage distributions, a beneficial effect for the United States, and a detrimental one for Mexico.

Wage-Constrained Visa Policies In these scenarios we impose migration eligibility criteria for Mexican immigrants that depend on the wages that Mexicans earn in the United States. We only allow those Mexicans to migrate who earn above predefined thresholds: 20,000 USD, 50,000 USD, and 100,000 USD respectively; see Figure 6b.[45] In the United States, im-

[45]This policy resembles the United State's H-1B program, which limits the education levels and occupations of immigrants. A similar policy has been implemented in the



(a) Policy Experiments: Tariffs



(b) Policy Experiments: Income-constrained Visas

Note: Figure 6a depicts three scenarios that simulate 20 percent increases in trade tariffs imposed by the United States on Mexico (the double-dashed black line), imposed by Mexico on the United States (the long-dashed gray line), and a trade war between the United States and Mexico (the double-dashed light-gray line). Figure 6b depicts three scenarios that simulate the introduction of income-constrained visas for Mexicans based on their potential earnings in the United States: a cutoff at 20,000 USD (the long-dashed black line), a cutoff at 50,000 USD (the double-dashed gray line), and a cutoff at 100,000 USD (the solid light-gray line). The left (right, respectively) panel illustrates the relative changes in wages for U.S. citizens (Mexican stayers). The horizontal axes represent the quantiles of respective wage distributions.

posing wage-constrained visas has an unambiguously positive effect for the left tail of the wage distribution, and a detrimental impact on high earners. The cutoff that separates winners from losers is located around the median if the income threshold is 20,000 USD, exceeds 60 percent in case of a 50,000 USD threshold, and settles at 55 percent when immigrants must earn at least 100,000 USD. The market size effect decreases with the visa threshold, because a higher threshold implies that fewer Mexicans qualify for the visa. The resulting increase in the price index eventually dominates the distributive labor market effect: indeed, a policy with a threshold of 100,000 USD is dominated by a policy with a 50,000 USD threshold for

European Union (EU). European Blue Cards allow non-EU professional to settle in EU member states only if they earn more than the threshold established by individual countries.

almost all U.S. wage quantiles. In Mexico, the cutoff that separates winners from losers is less dependent on the threshold than in the case of the United States, as the U.S. and Mexican skills are only weakly correlated. However, all stayers in Mexico gain relatively more from the United States setting a higher immigration constraint (100,000 USD), than from setting a medium-sized earnings threshold (50,000 USD).

6 Conclusions

International migration has reached the forefront of contemporary economic, social, and political debates. It has recently gained unprecedented societal recognition, extensive media coverage, and has affected many electoral results over the last few years. Nonetheless, how to evaluate international migration's impact on welfare and wage inequality has remained an intensively debated problem. In this paper, we first point out that, given the real-world distribution of wages, changes in migration policy are likely to have qualitatively the same effect on the average and variance of natives' wages, which creates a conflict between the efficiency and equality goals of migration policy. Subsequently, by proposing a novel two-country model of migrant self-selection and assignment, we provide a fresh look at how changes in migration, trade, and education policies affect the size and quality of the migrant population and the welfare of the people living in the origin and destination countries. Our approach extends the model of Gola (2019) by combining the selection model in Roy (1951), the matching model in Sattinger (1979), and the trade theory in Krugman (1980) and Melitz (2003). By calibrating the model using Mexican and U.S. data for 2015, we quantify the way in which self-selection of Mexican immigrants to the United States determines the distributive welfare implications of migration in both countries.

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