Let's be selective about migrant self-selection*

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Abstract

The self-selection of migrants is a central topic in the study of migration. While a large literature studies the nature and causes of self-selection, little is known about its consequences. In this paper we quantify the aggregate impact of selective migration on income per capita and inequality in the sending and receiving countries, looking at the large migration waves from Norway to the US in the 1880s and from Mexico to the US in the 2000s. We estimate non-parametrically the degree of selection from both countries. Based on a calibrated general equilibrium model, we compare the economy under the observed migration with an economy with neutrally selected migrants. Our findings show that self-selection can have a substantial impact on welfare, but only if both the migration flow and the degree of selectivity are sufficiently large. The effects are zero for the Norwegian case, and large for the Mexican case. Negative selection increased Mexican GDP pc by 1.7%, while it decreased US GDP pc by 0.2%. In Mexico, the selection effect is larger than the aggregate scale effect of migration, while it is 50% of the scale effect in the US.

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1 Introduction

Migrant self-selection — the question who migrates and who doesn't — is one of the most fundamental issues in the economics of migration. A large literature has studied the *if* and *why* of self-selection: to what extent are migrants and non-migrants different, and what causes this difference? Despite the vast evidence of migrant self-selection from sending countries around the world, it is not clear what consequences selective migration. In this paper, we quantify the aggregate effect of migrant self-selection on the level and distribution of incomes in the sending and receiving countries.

We study the emigration from Norway in the 1880s and the emigration from Mexico in the 2000s as examples of the two largest migration waves in the history of the US. Both countries experienced and outflow of 9% of their population, yet the selection of migrants differed fundamentally. As Figure 1 shows, Norwegian migrants had almost the same skills as the total population, whereas Mexican migrants were significantly less-skilled.[1] This difference allows us to quantify the aggregate effect of self-selection under different policy regimes and macroeconomic conditions.

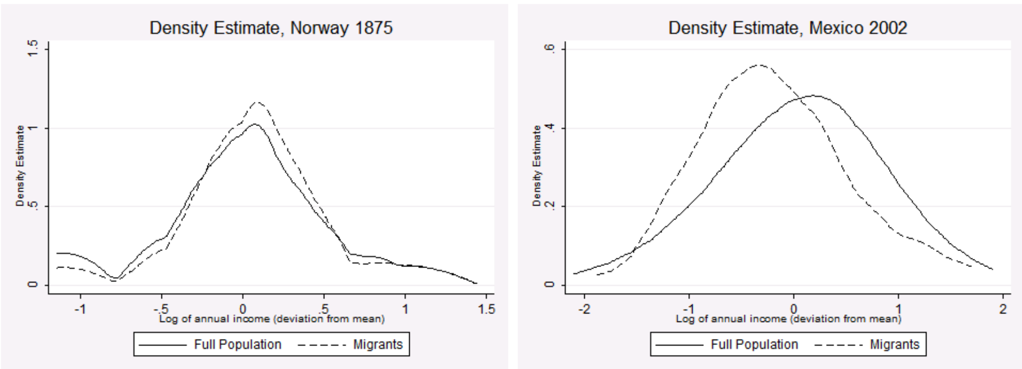

Figure 1: Selection of Migrants, Norway 1875 and Mexico 2002

Our analysis combines non-parametric estimation with a calibrated simulation exercise. We first estimate the skill distributions for migrants and the total population, and calculate the degree of selection as the difference between both distributions. For both countries we use panel data that contains information on pre-migration earnings and subsequent migration decisions, allowing us to identify migrants in the wage distribution of the total population. For Norway, we obtain this data by matching people from the Norwegian census in 1875 to Norwegian immigrants in the US census in 1880. For Mexico, no such exercise is needed, as the Mexican Family and Life Survey (MxFLS) has

[1] Section 4 explains the details on how these distributions are obtained.

information on pre-migration earnings.

To quantify the aggregate impact of migrant self-selection, we use a general equilibrium model with heterogeneous workers, put forward by Yeaple (2005) and Iranzo & Peri (2009). We calibrate the model on the economies of the sending and receiving countries, and compare the economy under the observed selective migration to an economy in which all migrants were neutrally selected. A change in the selection pattern affects real income per capita through a simultaneous impact on nominal wages and prices. It affects nominal wages by introducing more labor market competition for workers with some skills, and less for others, and it changes the overall price-level due to a re-allocation of labor between a traditional and a modern sector.

Our findings demonstrate that migrant selection can have a substantial aggregate impact under two conditions: a sufficiently large share of migrants, and a significant degree of selection. The migration of 183,000 Norwegians, for example, is large relative to the 2 million Norwegians in 1880, while it is very small compared to the 50 million US citizens at the time. Moreover, as shown in Figure 1, Norwegian emigrants had almost the same skills as the total population, resulting in a zero effect on the US economy, and mild effects on the Norwegian economy.

For Mexico, the migration flow was large, even compared to the native US population. The migration of 10 million Mexicans decreased the population in Mexico by 9%, and increased the US population by 4%. Due to its strong negative selection, Mexican migration left its mark on the economy of both countries. It reduced American real income per capita by 0.8%, while it increased Mexican income per capita by 1.7%. In Mexico, the selection effect is larger than the pure scale effect of migration — the GDP difference between autarky and the current level of migration, showing that the composition of migration flows can be as important as its scale. Besides the significant effects on the income level, self-selection we also find that migration has only a marginal effect on wage inequality.

This paper contributes to at least three strands of the migration literature. First, it shows that, under certain conditions, migrant self-selection can have substantial consequences for the economies of the sending and receiving countries, and thus complements the vast literature on the causes of selective migration.[2] In combination with the works of Abramitzky *et al.* (2012) on Norway and of several authors on Mexico (Chiquiar & Hanson, 2005; Fernández-Huertas Moraga, 2011, 2013; Kaestner & Malamud, 2013; Ambrosini & Peri, 2012), our paper provides the reader with a complete picture of the causes

[2] We will review the literature on the causes of selection in Section 2.

and consequences of selective migration.

Second, by showing that the composition of the migration flow can be as important as its size, this paper advances the literature on the aggregate gains from migration. A series of papers quantifies the impact of migration on GDP using calibrated general equilibrium models. In large parts, these studies take the status quo as a benchmark, and estimate the welfare effect of a further reduction in the barriers to international migration (Hamilton & Whalley, 1984; Felbermayr & Kohler, 2007; Klein & Ventura, 2007, 2009; Iranzo & Peri, 2009; Docquier *et al.*, 2012; Kennan, 2013), or take as counterfactual a world without migration (Di Giovanni *et al.*, 2012). Depending on the modelling framework and the data, these papers predict significant overall gains from migration. Compared to these studies, we make two advances. While other studies mainly focus on changes in the size of the migration flows, we show that sizable welfare effects can even arise if we observed migration flows at the same level, but with a different skill composition. Also, due to data limitations, most of these studies only consider two groups of workers - high-skilled and low-skilled. Because we can rely on rich micro data, we are able to quantify the impact of migration along the entire skill distribution.

This paper can also inform the literature on the optimal design of migration policy (Fernández-Huertas Moraga & Rapoport, 2011; Djajić *et al.*, 2012). Through border enforcement and selective visa policies, governments in receiving countries can influence the selection of migrants in order to maximize gains from migration or voter shares (Facchini & Testa, 2011). Our paper suggests that such policies can impose a substantial negative externality on the sending country, and may hit small sending countries particularly hard. Designing a compensation scheme would be difficult, especially if the losses in the sending countries are greater than the gains in the receiving countries.

2 Self-selection: what does the literature say?

Since the seminal work of Borjas (1987), migrant self-selection has been a central topic in the economics of migration. Borjas' theory shows that the selection of migrants is driven by the difference in the wage distributions of the sending and receiving countries. If the receiving country is more equal, it will receive predominantly migrants from the bottom of the skill distribution, while it will attract migrants from the top of the skill distribution if the wage distribution is more unequal than in the sending country.

Numerous scholars have since tested this idea empirically for a large number of countries. The most prominent case is US-Mexican migration. While earlier work shows that Mexicans are neutrally selected from the middle of the skill distribution (Chiquiar & Hanson, 2005; Ibarraran & Lubotsky, 2007; Orrenius & Zavodny, 2005), more recent studies have challenged this view. With the availability of panel data that included information on pre-migration earnings, Fernández-Huertas Moraga (2011, 2013), Kaestner & Malamud (2013) and Ambrosini & Peri (2012), among others, showed that Mexican migrants were negatively selected from the population, a finding consistent with ours.

A number of studies present historical evidence for the self-selection of migrants. Abramitzky *et al.* (2012), for example, consider Norway in the late-19th century, showing that migrants were negatively selected from rural areas and positively selected from urban areas. Consistent with our findings, they show that the overall selection was mildly positive. Baten & Stolz (2012) find evidence in favor of the Borjas model for a sample of more than 50 countries in the 19th century. Collins & Wanamaker (2013) use matched US census data to study the selection of African-Americans during the Great Migration at the beginning of the 20th century, showing that migrants were positively selected.

Besides the selectivity of emigration, it is also interesting who stays in the source country and who eventually returns home. Borjas & Bratsberg (1996) provide a theoretical framework which shows that - depending on the skill premia in sending and receiving countries - permanent migrants are either the best of the best, or the worst of the worst, while return migrants are the intermediate case. Biavaschi (2013) considers outmigration from the US for over 50 years in the middle of the 20th century, and shows that outmigrants have been negatively selected among all migrants, although the degree of selection decreased over time.

While the literature by-and-large focuses on the selection according to skills, which are either measured by education levels or wages, recent studies show that migrant selection also occurs along other, potentially important dimensions. (Delaney *et al.*, 2011) shows that Irish migrants in the UK were negatively selected. (Umblijs, 2012) considers risk-aversion, and shows that migrants are more risk-loving than non-migrants. We do acknowledge that education and wage levels are an incomplete representation of a person's actual skills. However, to make our results comparable with the previous literature, we will focus on wages as a reduced-form representation of skills.

3 Migrant self-selection in a model with heterogeneous workers

3.1 Some intuition

To determine the aggregate impact of migrant self-selection on per-capita income and income inequality, we rely on a general equilibrium model with heterogenous workers. The model will allow us to simulate the effect of different migration scenarios on the sending and receiving countries. Before going into the analytics of the model, we provide some basic intuition for the simulation exercise. Consider a world that consists of two countries — for simplicity, call them Mexico and the US. Both are endowed with high-skilled and low-skilled workers, as described by the Edgeworth box in Figure 2.

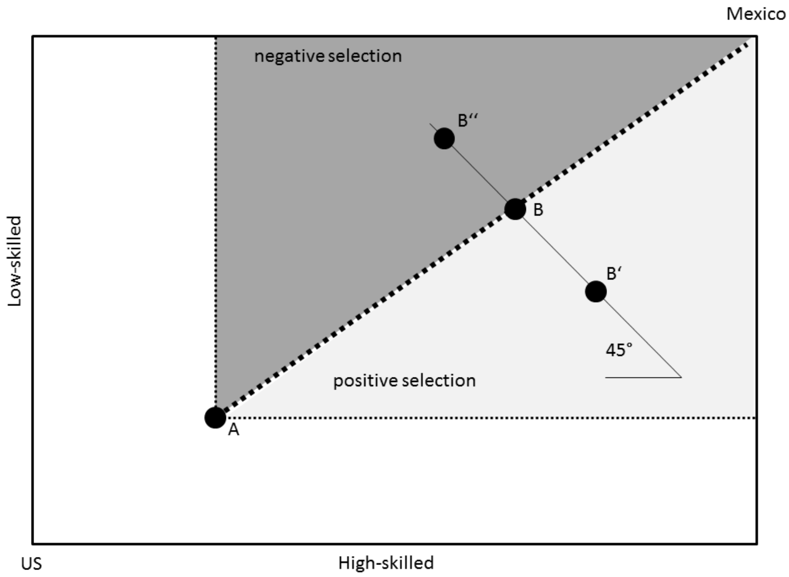

Figure 2: Migration from Mexico to the US. A: initial endowments without migration.

Let A denote the endowment in autarky, before any migration happened. If workers migrate from Mexico to the US, the endowment point moves from A towards the upper right corner within the shaded area. If the endowment after migration lies on the dashed line from A to the upper right corner, migrants are neutrally selected, as the ratio between high- and low-skilled workers is the same for emigrants and the entire Mexican population, as shown in point B. If the new endowment lies north-west of the neutral selection line; if it lies south-east, migrants are negatively selected. Points B' and B", which lie on a 45°-line through B, represent migration flows with the same number of migrants as in B, but a negative and positive selection, respectively.

In the simulation exercise, we will compare the economy under the observed migration pattern, for example B', with an economy under neutral selection in point B. This strategy is conceptually different from the one applied in other studies, who either quantify the difference between autarky A and currently observed migration B' (Di Giovanni *et al.*, 2012), or between B' and a new endowment point that lies between B' and the upper right corner (e.g. Docquier *et al.* (2012), Kennan (2013)).

3.2 Basic model

Having laid out the basic intuition of our research design, we now describe the mechanics of the model. The model is based on heterogeneous workers, allowing us to study both aggregate and distributional effects of selective migration. It closely follows the work of Iranzo & Peri (2009), who use a simplified version of a model developed by Yeaple (2005) to study the aggregate impacts of trade and labor market integration Europe. We will restrict the description of the model to its most important features, and refer the interested reader to Iranzo & Peri (2009) for a full account.

We consider each country in autarky, assuming that trade flows do not respond to changes in the skill composition of migrants. To make GDP and wages comparable across countries, we account for differences in total factor productivity (TFP), denoted by Λ. Each country is populated with a continuum of M workers with skills $Z \in [0, 1]$, with a cumulative density function $G(Z)$. The economy consists of two sectors, X and Y. Sector Y can be understood as the more traditional sector, requiring mostly manual-intensive and routine tasks. Sector X is the modern sector, involving complex tasks.

Sector Y is perfectly competitive, and produces a homogeneous good with a constant returns to scale technology. Sector X produces N varieties of a differentiated good. Firms can freely enter sector X after paying a fixed cost F_X in the form of foregone output. The production technology in sector X exhibits a higher degree of capital-skill complementarity g_X than the technology in sector Y, g_Y, so that workers with higher skill levels Z have a comparative advantage in sector X. All workers above a threshold level $\bar{Z}$ will sort into sector X, while workers with skills below $\bar{Z}$ will sort into sector Y. $\bar{Z}$ is determined endogenously in equilibrium.

A worker in each sector produces A_Y and A_X units of goods Y and X, respectively, with

$$\begin{aligned} A_Y(Z) &= \exp(g_Y Z) \\ A_X(Z) &= \exp(g_X Z). \end{aligned} \quad (1)$$

Workers are paid their marginal product, such that unit costs are equalized across all skill levels within a sector. That is, the ratio of wage $W(Z)$ and productivity,$A_Y(Z)$ or $A_X(Z)$, is constant within each sector. The worker at the cutoff skill level $\bar{Z}$ is indifferent between working in both sectors, as she receives the same wage in both $W_X(\bar{Z}) = W_Y(\bar{Z})$. In equilibrium, the wage schedule is

$$W(Z) = \begin{cases} \Lambda \exp(g_Y Z) & 0 \leq Z \leq \bar{Z} \\ \Lambda C_X \exp(g_X Z) & \bar{Z} \leq Z \leq 1 \end{cases}, \quad (2)$$

with $C_X = \exp(g_Y \bar{Z}) / \exp(g_X \bar{Z}) < C_Y$ being the unit costs in sector X. Note that Y is the numeraire, so that $C_Y = P_Y = 1$.
Figure 3 illustrates the wage schedule in equilibrium. The wage schedule is linear in Z, with a kink at $\bar{Z}$ due to the higher returns to skill in sector X. The average nominal wage in equilibrium is

$$\bar{W} = \Lambda \left(\int_0^{\bar{Z}} \exp(g_Y Z) dG(Z) + C_X \int_{\bar{Z}}^1 \exp(g_X Z) dG(Z) \right). \quad (3)$$

To obtain real wages, $\bar{W}$ has to be divided by the aggregate price index $P = \left[\beta^\theta P_X^{1-\theta} + (1-\beta)^\theta\right]^{\frac{1}{1-\theta}}$, with $P_X = [\int_0^N p(i)^{1-\sigma} di]^{\frac{1}{1-\sigma}}$ being the price index for the differentiated good X.[3]

3.3 Introducing migration into the model

We now introduce migration into the model and derive predictions for the effect of a change in migrant selection on income per capita and wage inequality. To measure the aggregate impact of migrant selection, we conduct the following thought experiment. We start with migration *as observed*, which means that out of the population M, a fraction $\alpha \in [0, 1]$ with skill distribution $G_M(Z)$ have migrated from the sending to the receiving country. We then repatriate all αM_S migrants with skills $G_M(Z)$, and draw αM_S new

[3] β is the share of good X in the consumer's utility function, θ and σ are the elasticities of substitution between goods X and Y and between N varieties of X, respectively.

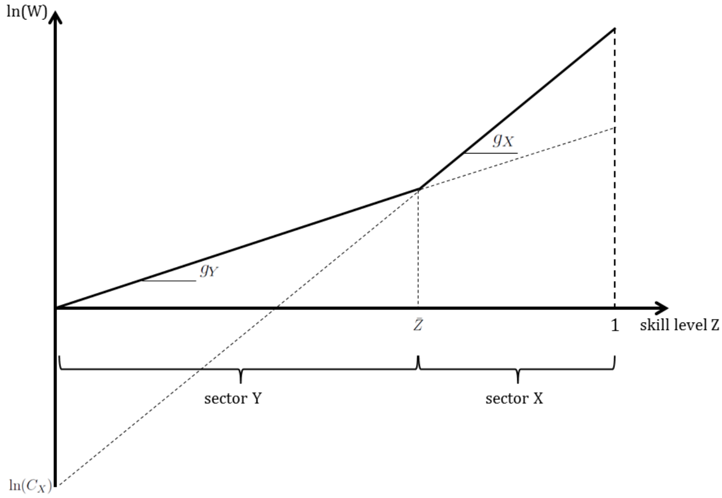

Figure 3: Equilibrium wage schedule.

Note: See Iranzo & Peri (2009). The equilibrium wage schedule is the upper envelope of the wage schedule in sectors Y and X. Workers self-select into the sector that pays a higher wage. The vertical axis denotes the log nominal wage in terms of the numeraire.

migrants from the total population, which has a skill distribution $G_S(Z)$.

We speak of positive selection if migrants have on average a higher skill-level than all nationals of the sending country. Formally, this translates into first-order stochastic dominance of $G_M(Z) \leq G_S(Z)$. Migrants are

$$\begin{array}{lll} \text{positively selected} & \text{if} & G_M(Z) \leq G_S(Z) \quad \forall Z \\ \text{neutrally selected} & \text{if} & G_M(Z) = G_S(Z) \quad \forall Z \\ \text{negatively selected} & \text{if} & G_M(Z) \geq G_S(Z) \quad \forall Z. \end{array}$$

As an example, Figure 4 illustrates the effect of negative selection of migrants on the economy in the sending country. The increase in the average skill level of the workforce increases the productivity in the X-sector, thereby reducing the unit costs of production in sector X. This leads to a downward-shift in nominal wages in sector X, and a shift in the cutoff between Y and X to the right. The relative wage decrease in sector X can be interpreted as a competition effect on the labor market. More high-skilled workers increase competition and reduce nominal wages. At the same time, the sectoral re-allocation from the traditional to the modern sector reduces the aggregate price level. The average worker in sector X becomes more productive, so that one unit of a given variety can be produced at lower cost, leading to lower relative prices for each unit of X

in terms of the numeraire.

Taken together, the effect on real wages depends on the sector. Real wages in sector Y increase due to lower prices, while the effect in sector X can be positive or negative, depending on whether the wage or the price effect dominates. In the receiving country, negative selection has the opposite effect on real wages. Overall, the effect of migrant selection on per-capita income and inequality will depend on the structural parameters that characterize consumers and firms in each country, as well as the scale and composition of the migration flows.

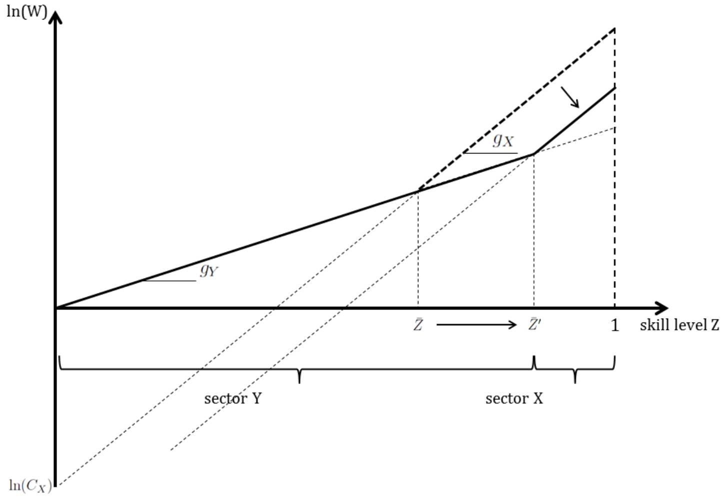

Figure 4: The impact of negative selection in the sending country.

Note: This figure illustrates the impact of a negative selection on the equilibrium wage schedule in the sending countries. If workers become more skilled on average, the cutoff skill level $\bar{Z}$ shifts to the right, leading to lower nominal wages in sector X.

4 Estimating the degree of self-selection

We now turn to the estimation of the skill distributions. For each sending country, we require the skill distribution of migrants $G_M(Z)$ and of the total population $G_S(Z)$. In Figure 1 we have already shown the distributions for Norway and Mexico. In this section we explain how we estimate them.

We use a simple metric to measure selection: the difference in pre-migration earnings between migrants and the total population. Earnings can be understood as a reduced form representation of a worker's productivity, including both observable factors, such as education and experience, and unobservable factors, such as industry affiliation, motivation, self-confidence, etc. If migrants were positively selected from the home population, we would expect their higher skill levels to translate into higher earnings before migration. The opposite would be true in the presence of negative selection. The advantage of this procedure is that it avoids more complex exercises aiming at recovering counterfactual wage distributions for the two subgroups such as those in Chiquiar & Hanson (2005) and Biavaschi (2012). In the following, we give a brief historical summary of each migration wave, and describe the data sources, the estimation strategy, and address potential empirical challenges.

4.1 Norway

Emigration from Norway is an illustrative example for the mass migration from Europe to the US in the second half of the 19th century, in particular from Scandinavia. Jensen (1931) reports that while up to the 1860s Scandinavian emigration rates were below the European average, the pattern reversed in later periods, with emigration substantially exceeding European rates. Between 1875 and 1880, the emigration rate from Scandinavia was more than 5 times as large as in the rest of Europe, with Norway driving this pattern. Figure 5 shows the share of emigrants among the total population in five-year intervals for the last 160 years. These emigration rates are substantial, and second only to Irish emigration rates at the time.

Besides being one of the most important sending countries during the age of mass migration, Norway offers the advantage of having almost complete digitalized censuses, allowing us to observe a large starting population. Our goal is to look at the Norwegian population at one point in time and attach to each individual an indicator of whether he will have migrated or not within a few years. To do that we use census sources on both sides. We first consider the 1880 U.S. Census, which is the only U.S. Census that has been fully digitalized (Minnesota Population Center, 2008). For Norway, a 100% Census is available in 1865 and a partially digitalized census in 1875.

We use the 1875 Census for several reasons. First, it gives us a larger sample size due to a less stringent age-restriction. Recall that we need individuals in the labor force before migration; the shorter time-span between the two Census enumerations allows us to keep all individuals 15-45 years old in 1875. Second, the shorter time span reduces measurement error due to selective mortality. Third, using the 1875 Census we can

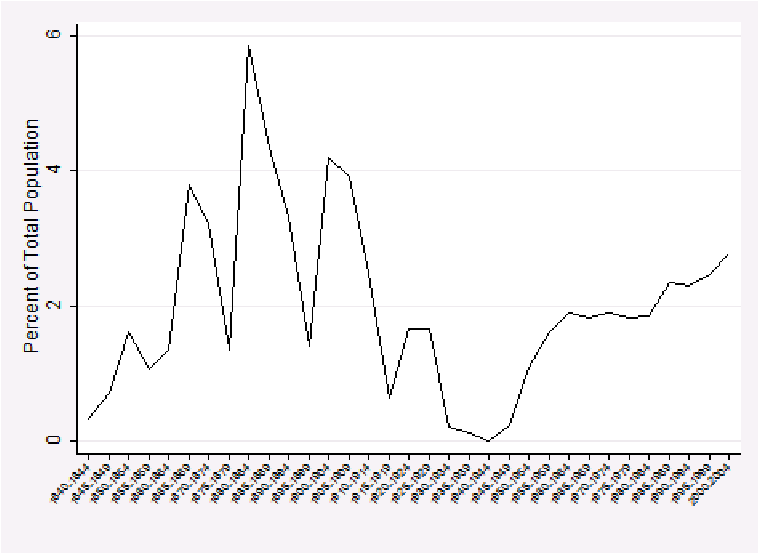

Figure 5: Percentage of Emigrants in five-year intervals among the total population, Norway

Source: Norwegian Statistics.

compare our selection results with those in Abramitzky *et al.* (2012), who matched the population 3-15 years old in 1865 to the 1900 U.S. and Norwegian Census. Hence, the selection patterns of our migrants 15-25 years old should be similar to those found by these authors if selection has been relatively stable over time. Note that using the same sample as Abramitzky et al. is impossible, as we need population working in 1865, and survival rates by 1900 are likely to be too low due to a life expectancy of about 50 years.

Data and Descriptive Statistics We start from the 1875 Norwegian Census which includes a 100% sampling for all of northern Norway, large cities and scattered municipalities, as well as a 2% sampling for the rest of the municipalities. There are 642,937 person records. We focus on individual 15-40 years old in 1875 and match them with the Norwegian-born in the 1880 U.S. Census. Over 95% of Norwegian emigration settled in the U.S., hence these sources should capture completely the migration flows and their selection pattern during this time period (Jensen, 1931).

Our matching procedure is based on a unique combination of name, surname and age. We cannot use further matching criteria such as province of birth as this information is not available in the U.S. Census. The matching procedure follows an iterative algorithm that has become standard in the economic history literature (Ferrie, 1996; Abramitzky *et al.*, 2012).

- We identify 115,580 Norwegian men in the 1875 Census 15 to 40 years old of which 54,070 are unique by name and age combinations. We keep only the unique combinations of name and age. The are 36,540 Norwegian-born men in the 1880 U.S. Census of age 20-45. Of these, 19,179 have unique combination of name and age.
- We standardize all first and last names using the NYSIIS algorithm.
- We first match by name and exact age. If a unique match is found, the observation is considered as matched. We then proceed by matching within a one year band around the age. We delete duplicate matches, i.e. different individuals in 1875 matched to the same individual in 1880 and multiple individuals in 1880 matched to one individual in 1875. This procedure yields to a total sample of 2,238 migrants and 51,102 non-migrants. The implied emigration rate is 4.20 %.[4]

Measuring selection in the early Censuses creates a further challenge: literacy, education measures and wages are not available. It is therefore necessary to rely only on differences in the occupational distribution of migrants and stayers and assign mean earnings by occupation. Reliance on mean earnings implies that selection can only be measured by variation across occupations and not within occupations. For instance, negative selection should be interpreted as migrants holding lower skilled occupations, although it might well be that within low-skilled occupations they are the highest ability workers. We use the crosswalk between HISCO occupations and mean earnings provided by Abramitzky et al, who match income levels from Statistics Norway and other sources for 1900 and estimate incomes for farmers, fishermen and white collar workers. The analysis is only carried out for occupations with an available estimate of average earnings (about 70.53% of the sample), laying within 2 standard deviations from the mean earnings.

We define as migrants all individuals in the 1875 Norwegian census that we find in the 1880 census; everybody else is defined as a non-migrant. Using pre-migration earnings as a measure of selection complements the evidence given in Abramitzky et al., which was based on a cross-country comparison of income for migrant and non-migrant brothers. By matching the migrants only, we avoid having to rely on a fully matched sample that might be non-randomly selected due to the obvious challenges involving historical record linkage. On the other hand, as we are not matching the stayers five years later, this group might include migrants that could not be found in the U.S. census, either because

[4] This is about twice as large as the official emigration rate from Norwegian Statistics. If there is a concern in the matching procedure, this should be that some of the stayers wrongly appear to be migrants.

of limitations in the matching procedure, or because of mortality. However, mortality within a five-year span should only play a residual role. As an extra check, we will report selection measures focusing on 15-35 years old only.

If there is measurement error in the sample of stayers, our measures of selection will not be affected as long as the non-matches exhibits characteristics similar to the matched migrants. The current draft of the paper relies on this assumption, while future work will construct a a sample in which also the stayers are matched and compare the results.

Migrant Selection in Norway Table 4 shows the characteristics of migrants and non-migrants before migration. Migrants have higher pre-migration income (0.06 log-points), are older, are more likely to reside in cities, and more likely to have more than three children.[5]

Our empirical exercise goes beyond the simple average difference between the groups as we study self-selection as a change in the whole earnings *distribution*. We estimate the earnings distribution for migrants and non-migrants in 1875 and compare them. This provides a non-parametric measure of selection that is fully flexible and captures the impact of self-selection beyond changes in means, on all moments of the earnings distribution.

Figure 6 shows the estimates for $G_M(Z)$ and $G_S(Z)$, the cumulative earnings distribution functions of the migrants and the total population.[6] Migrants from Norway were on average positively selected. $G_M(Z)$ stochastically dominates $G_S(Z)$, although the difference (shown in figure 6b) is rather small. The second panel of Figure 6 shows the difference in the skill distributions of the migrants and the total population, pointing again to a mild positive selection. The Kolmogorov-Smirnov test statistic for equality of both distributions gives a D-statistic of 0.0674 with an associated p-value of less than 0.001, indicating that the migrants' earnings are statistically different from those in the total population.

[5] Abramitzky *et al.* (2012) find that migrants are on average positively selected, although selection is small. Substantial skill differences arise in their results when comparing urban and rural migrants. We have run complementary OLS regressions and identified the same pattern also in our dataset: migrants from rural areas are positively selected, i.e. earn more than the non-migrants, while migrants in urban areas seem to underperform the urban non-migrants. The positive selection of the rural migrants reduces as further controls for province of residence are added, indicating that much of the selection is driven by across-province differential selection. The negative selection from cities, on the other hand, persists in all regressions. These results are consistent with selection patterns in Abramitzky et al., hence complementing their analysis. Results are available upon request.

[6] See Figure 1 for the corresponding Kernel density plots.

4.2 Mexico

Mexicans accounted for the majority of migrants in the most recent wave of mass migration to the US. The immigrations of workers from Latin America since the 1980s increased the share of the foreign-born in the US to 15%, the same share as before World War I. The degree of selection of Mexican workers has been an ongoing subject in the literature. Earlier studies based on cross-sectional data, for example (Chiquiar & Hanson, 2005), show that Mexicans were selected from the center of the skill distribution, while more recent studies, based on panel data, find the selection pattern to be negative (Fernández-Huertas Moraga, 2011; Ambrosini & Peri, 2012).

Data and Descriptive Statistics To recover the distributions of interest we use the Mexican Family Life Survey (MxFLS). The MxFLS is a longitudinal dataset which collects information on socioeconomic indicators, demographics and health indicators of about 8,000 Mexican households. MxFLS is the first nationally representative longitudinal survey in Mexico, and conducted by the Instituto Nacional de Estadistica Geografica e Informatica (INEGI), the principal Mexican statistical agency. The baseline (MxFLS-1) was conducted during 2002. The second wave of field work (MxFLS-2) was conducted during 2005-2006 with a 90 per cent re-contacting rate at household levels. The interesting feature of the MxFLS is that it follows household members regardless of their decision to reside in Mexico or in the United States. We are therefore able to identify all the relevant socio-economic characteristics of migrants before emigration.

As in the Norwegian case, we define Mexican stayers as individuals who are found in Mexico in 2002 and in 2005. Note that this definition considers as Mexican stayers all those individuals who moved to the U.S. and returned to Mexico by 2002. We define to be migrants those individuals who were in Mexico in 2002 and move to he U.S. in 2005. The final dataset comprises all the 2002 data, with an identifier for all people who will migrate after 2002. We restrict the sample to men between 25 to 65 years, whose information on education and income is available in 2002 [7] and who lie within two standard deviations from the mean, resulting in a sample size of 4,778.

Migrant Selection in Mexico The second panel of Table 4 shows the characteristics of migrants and non-migrants before migration in Mexico. Migrants seem negatively selected, as indicated by the lower pre-migration income (0.41 log-points), of

[7] About 0.45% of the sample has missing information on education and 0.30% on income.

younger age and lower educational attainment. To further explore the relationship between earnings and migration status, we run a simple OLS regression, where we relate log-earnings with migration status, education, a quadratic in age, and controls for state of residence. As can be seen in Table 5, negative selection persists after controlling for observable characteristics. Furthermore, selection not only occurs in form of lower average earnings, but also in the form of lower returns to education. Migrants earn about 20 log points less than stayers prior migration. The strong and significant pattern of negative selection is consistent with recent findings in the literature (Fernández-Huertas Moraga, 2011; Ambrosini & Peri, 2012).

We continue as before by estimating the earnings distribution for migrants and non-migrants in 2002. Figure 7 represents the cumulative density functions of migrants and non-migrants as well as the difference in the migrant and home population skill distributions. The migrant earnings distribution lies to the left of the non-migrant distribution (Figure 7a) and, consequently, the difference in skill between the migrant and the home population shows a larger probability mass below average earnings (Figure 7b). Clearly, migrants are negatively selected compared to the total population. The Kolmogorov-Smirnov test statistic for equality in the migrant and counterfactual distribution gives a D-statistic of 0.1489 with associated p-value of less than 0.001, indicating that migrants' earnings differ from those in the overall population, and that this difference is statistically significant.

4.3 U.S.

In our simulation exercise we calculate the effects of selection on both the source and the receiving countries. To understand the aggregate effect on the U.S. economy, the migrants need to be compared to the natives.

The cumulative distributions for natives, migrants from Norway and Mexico, and migrants from all other sending countries, are shown in Figure 8 and the associated deciles in Table 6. For the 1880 sample, the estimation is restricted to males between 15-55 years and the income variable represents the mean occupational score according to the U.S. occupational distribution in 1950, which allows us to rank individuals by nativity status using a consistent definition covering more than 200 occupations. Both the table and the figure show that Norwegian migrants were rather similar to the native population, while the other migrants were better performing and much more positively selected.

For the 2002 U.S. sample, we use the American Community Survey (ACS) of that year. We focus on currently working males between 25-65 years, and report the earnings distribution for Mexican born, native and other migrant workers. As shown in Figure 8 and in the second panel of Table 6, Mexican workers are much more likely to be engaged in low skilled jobs, compared to natives and other migrants. Natives and migrants of other nationalities have very similar occupational distributions.

The immigrant skill distributions shown in Figure 8 represent the baseline for the effect on the receiving countries. Constructing the counterfactual is challenging, because the counterfactual skill distribution is estimated over the support of incomes in the sending country. However, being in the 9th decile in the Mexican distribution hardly means being in the 9th decile in the United States. The same skills may be rewarded differently in the US than in Mexico, and migrants and natives with the same observable characteristics are not necessarily perfect substitutes in the US labor market(**??**).

To make the skills of neutrally selected immigrants comparable with those of US natives, we discount them using the relative difference between the observed skill distribution of immigrants in the US and in the sending country as weights. To obtain the counterfactual skill distribution of immigrants in the US, we multiply the population in the sending country in the i-th decile, $d_{i,home}^{Pop}$, with a weighting factor consisting of the share of migrants in decile i in the host country earnings distribution, $d_{i,host}^{Mig}$, over the share of migrants in decile i in home country earnings distribution,

$$d_{i,host}^{Count} = d_{i,home}^{Pop} * \frac{d_{i,host}^{Mig}}{d_{i,home}^{Mig}}.$$

$d_{i,host}^{Count}$ is then divided by the sum of all weights $\sum_i d_{i,host}^{Mig}/d_{i,home}^{Mig}$ so that the deciles of the counterfactual distribution sum to one. As an example, Figure 9 shows both the unweighted and weighted counterfactual distributions for Norwegian and Mexican-born workers in the U.S. in 1880 and 2002. As can be seen, for Norwegians re-weighting only slightly modifies the counterfactual due to the small degree of selection, while the for Mexico it results in a larger mass of people in the lower quintiles of the earnings distribution. Yet, compared to the current distribution of earnings for Mexican immigrants, we would also have a larger mass of higher skilled migrants, as selection would be reduced.

5 The aggregate impact of self-selection

We now turn to the aggregate effects of selective migration. In a thought experiment, we compare the real income per capita and real wage inequality under the observed migration patterns with a scenario in which migration occurs at the same level, but migrants have the same skills as all nationals of the source country. The difference between baseline and counterfactual gives us the aggregate effect of migrant self-selection. As a first step, we calibrate the model outlined in Section 3 on the economies of Norway and the US in 1880, and Mexico and the US in 2000. We then feed in the estimated skill distributions of migrants and non-migrants from Section 4, and calculate the difference in aggregate outcomes under different migration regimes.

5.1 Calibration

To simulate the aggregate impact of selective migration, the structural parameters of the model need to be calibrated. We take most parameters from the literature, or calculate them from available data sources. For parameters that cannot be calculated, we pick values values such that key moments generated by the model match the real world data. Table 1 summarizes the calibration of the model parameters.

Table 1: Parameters for calibration

	Parameter	Norway 1880	USA 1880	Mexico 2002	USA 2002
External parameters					
Returns to skill, sector Y	g_Y	1	1	1	1
Population: stayers, natives		1,819	50,000	101,826	244,000
Emigrants to US		183		10,017	
Immigrant stock, all countries			1,414		26,588
TFP	Λ	0.3195	1	0.286	1
Internal parameters					
Returns to skill, sector X	g_X	1.23	2.77	2.81	2.41
Fixed cost in sector X	F_X	1,542	18,555	58.1	16.9
Preference share of X	β	0.48	0.35	0.55	0.46
Elasticity of substitution X and Y	θ	1.52	2.02	1.28	1.43
Elasticity of substitution, varieties of X	σ	3.92	3.18	3.82	3.69

Note: Population and migrant numbers in 1000s.

The population in is measured as the number of non-migrants in the sending countries and natives in the receiving countries. The migrant numbers are taken from the censuses of the receiving countries. The sources are: for the number of natives and immigrants the US census in 1880 and the American Community Survey (ACS) in 2002; for non-migrants in Norway the Norwegian census in 1875, and for non-migrants in Mexico the OECD population statistics in 2002. TFP in the US is normalized to one. The TFP level for Norway is based on Williamson (1995). For the difference in TFP between Mexico and the US in 2002, we use the differences in labor productivity levels provided by the OECD.

As in the theoretical model, sector Y is the traditional sector, with lower returns to skill, while X is the sector with more complex production processes and higher returns to skill. We divide the workforce in both sectors with respect to the complexity of tasks in their occupation. This classification is, of course, based on very different tasks in 1880 and in 2000. In Appendix B we explain which occupations fall into each sector. We normalize the returns to skill in sector Y to one, and choose the returns in sector X, g_X, together with the fixed costs F_X and the preference parameters β, θ and σ such that the distance between the moments generated by the model and the corresponding moments in the data is minimized.[8]

Table 2: Model fit: generated vs. target moments

	Norway 1880		**USA 1880**		**Mexico 2002**		**USA 2002**	
	target	model	target	model	target	model	target	model
Share in sector Y	0.83	0.84	0.79	0.74	0.41	0.44	0.26	0.31
Gini	38.5	39.4	36.9	46.1	46.0	49.7	46.5	49.2
2nd quintile	0.88	0.64	0.80	0.61	0.57	0.62	0.54	0.57
4th quintile	0.93	0.82	1.14	0.82	0.87	0.77	0.80	0.70
5th quintile	1.32	1.32	1.37	1.34	1.70	1.69	1.61	1.58

Note: This table shows the target moments and the corresponding moments generated by the model based on the calibrated. Target gini index and wage quintiles are calculated from deciles of the wage distribution. The wage quintiles are centered to the mean.

Table 2 shows the difference between the target moments and the corresponding moments generated by the calibrated model. Despite the model being relatively simple, it matches key moments of the data reasonably well.

5.2 Simulations

Based on the calibration shown in Table 1, we now simulate the changes in the skill distribution of migrants, and calculate its effects on sending and receiving countries.

[8] The moments are the share of workers in sector Y, the gini coefficient, and the first, second, and fourth quintile of the mean-centered wage distribution. For the preference parameters we choose the starting values as in Iranzo & Peri (2009), $\beta = 0.5$, $\theta = 1.5$ and $\sigma = 4$.

Before we turn to the results, let us first recall the predictions from the theoretical model. For the receiving countries, a more positive selection of migrants leads to a more skilled workforce, which shifts the cutoff skill-level between both sectors to the right, and decreases nominal wages in sector X. For sending countries, a more positive selection means the opposite, as the country is left with a less-skilled workforce. In both cases, the effect on real income per capita and real wage inequality is a priori ambiguous and depends on the model parameters, such as country size, productivity, skill distribution, substitution elasticities between different types of goods, and returns to education in different sectors. The same goes for the share of workers in both sectors. While an increase in the skill levels shifts the cutoff skill-level between Y and X to the right, this may not necessarily mean that sector Y will have a higher share of workers, as the sectoral distribution of workers depends on the size of the shift in the skill distribution.

The magnitude of the aggregate effects will depend on the share of migrants and the degree of selection. If the share of migrants is low compared to a country's population, the effects will be small regardless of the skill composition of the migrant flows. Given that in both cases, Norway and Mexico, people migrated from a smaller to a larger country, the relative population changes are naturally larger in the sending countries. As we can see in Table 1, the emigration of 183,000 Norwegians decreased the Norwegian population by 9%, while it only increased the US population by 0.4%. Likewise, the emigration of 10 million Mexicans to the US decreased the Mexican population by 9%; the increase in the US population was smaller, but still amounted to 4.1%. From these differences in population changes, we can expect the effects in the source countries to be larger than in the receiving countries.

Another determinant of the size of the effect will be the degree of migrant selection. The effects will be small if the degree of selection is small, that is, if migrants have almost the same characteristics as all nationals from the country of origin. As Figure 1 shows, the degree of selection was a lot smaller in Norway in 1880 than in Mexico in 2002. Therefore, we would expect larger effects for the Mexican case, even if all other parameters were the same as in Norway in 1880.

While the magnitude of the effects is determined by the size of the emigration rate and the degree of selection, the direction of the effect will depend on the nature of selection. Compared to neutral selection, we expect positive selection to have a positive impact on income per capita in the receiving country and negative effects in the source country, because the receiving country ends up with a higher skill level, whereas the sending country loses a higher share of high-skilled workers.

Table 3 depicts the gains and losses from selective migration, computed as the difference between baseline and counterfactual, relative to the baseline values. For example, the change in the price index in Norway in the first column means that because of selective migration, prices in Norway in 1880 were 0.08% lower than they would otherwise be.

Table 3: The gains and losses from migrant selection

	Sending countries		Receiving countries Only immigrants NOR & MEX		Receiving countries All immigrants	
	Norway 1880	Mexico 2002	USA 1880	USA 2002	USA 1880	USA 2002
	(1)	(2)	(3)	(4)	(5)	(6)
Changes in %						
Price index	-0.01	-1.56	-0.01	0.18	-0.12	0.51
Real income p.c.	-0.25	1.74	-0.12	0.02	-0.23	-0.79
Changes in percentage points						
Gini	-0.03	-0.45	-0.00	0.04	-0.01	0.12
Employment Y	-0.08	0.44	-0.02	0.00	0.00	0.02

The first two columns display the aggregate effects for the sending countries. For Norway, which had a slight positive selection of emigrants, this selection decreased GDP by 0.25%, and it decreased the GINI index by 0.03 points. Prices decreased by 0.01%, while the employment share in sector Y decreased by 0.08 percentage points. Overall the effects are very small for Norway, owing to the low degree of selectivity.

The effects are considerably larger in Mexico. While migrant selection contributed little to wage inequality and the sectoral distribution, it had a significant impact on the prices and real income per capita. Because the 10 million Mexicans who moved to the US were less skilled than the average Mexican, Mexican prices are 1.6% lower, and real incomes 1.7% higher. The effect of selection on GDP is larger than the scale effect of migration (moving from autarky to the observed migration), which is 1.6%.

The comparison between Mexico 2002 and Norway 1880 shows the importance of selection for aggregate outcomes. Both countries had the same share of emigrants, yet Norwegian migrants had almost the same skills as those who stayed in Norway, whereas Mexican migrants had fundamentally different skills, leading to larger effects in Mexico.

Columns (3) and (4) of Table 3 show the effects for the receiving countries. For the US in 1880, the inflow of 183,000 Norwegians only meant an incremental increase of the population, so that the composition of these flows had no impact on prices and incomes. Matters are different 120 years later. The fact that 10 million Mexicans coming to the

US were less-skilled than the average Mexican, has a noticeable effect on US income per capita. The negative selection of Mexicans increases aggregate prices by 0.18%, and decreases per capita income by 0.2%.

The relevance of selective migration is further highlighted in columns (5) and (6). We conduct the following thought experiment: suppose all immigrants that come to the US, had the skills of, respectively, Norwegians and Mexicans, what would be the aggregate effects? Owing to the small degree of selection, the effects for the US in 1880 are still negligible, even though all immigrants taken together constitute a significant share of the population. If, however, all immigrants were selected like Mexicans in 2002, the consequences for the US would be substantial. Prices would increase by 0.51% and income per capita would decrease by almost 1%.

6 Conclusion

Migrant self-selection — the extent to which people who migrate are different from those who don't — is a central issue in the study of migration. A large literature quantifies the degree of self-selection of migrants from source countries all over the world, and investigates the determinants of why some people move and others don't. While the scale and causes of self-selection have been well-documented, little is known about the effects of migrant self-selection.

This paper quantifies the aggregate impact of migrant self-selection on income per capita, prices, and income inequality in both sending and receiving countries. For this exercise, we use two mass migration episodes that occurred in different times, but at a similar scale: the migration of Norwegians to the US in 1880, and the migration of Mexicans to the US in 2000. In both cases, emigration decreased the population of the sending countries by 9%.

We first estimate the degree of self-selection for both countries, confirming previous findings from the literature that Norwegians were on average positively, and Mexicans negatively selected from the respective populations (Abramitzky *et al.*, 2012; Fernández-Huertas Moraga, 2011). To quantify the aggregate effect, we conduct the following thought experiment: we send all immigrants back to their sending country, and replace them by the same number drawn at random. Put differently, we compare aggregate outcomes under the observed selective migration flows with a counterfactual scenario, in which migrants have the same characteristics as all nationals of the sending country. For the simulations we use a general equilibrium model with heterogeneous workers, based on the work by Iranzo & Peri (2009) and Yeaple (2005), which we calibrate on the economies of Norway, Mexico, and the US in 1880 and 2002.

Our main finding is that migrant self-selection can matter for real income per capita and prices, but only if the share of migrants and the degree of selection are sufficiently large. Norwegian migrants in the 1880s had very similar skills compared to non-migrants, which leaves income per capita and prices in both Norway and the US unaffected. For the Mexican migration episode, however, our model predicts sizable aggregate effects. The negative self-selection of 10 million Mexicans decreases prices in Mexico by 1.5% and increases real income per capita by 2.5%. In the US, the effects are smaller, but the negative selection of Mexican immigrants still leaves Americans with 1% less in income per capita than they would have if Mexicans were neutrally selected.

These findings can have important implications for migration policies. Given the potential negative welfare effects of selective migration for receiving countries, it is not surprising that many receiving countries try to set migration policies that influence the selectivity of migration flows, for example through point systems. The US-Mexican case shows that selective immigration policy could in fact increase the welfare of US natives, but this selective policy also creates a negative externality for the sending countries. In particular, if people move from a smaller to a larger country, the welfare losses in the sending countries will be larger than the gains in the receiving country, giving rise to a serious coordination problem.

Besides that, the results should be interpreted with caution for at least two reasons. First, our definition of skills focuses on wages, which we understand as a reduced-form representation of human capital. Migrants may, however, differ from non-migrants in other respects that may not be captured by wage differences in the source country, but that may unfold in the receiving country. Important differences could be health, entrepreneurial talent, risk aversion, which could give rise to a different pattern of skill selection, and translate into different aggregate effects.

Also, our welfare calculations only measure a contemporaneous effect, and omit externalities that may come into play in the long run, potentially only after one or more generations. We may well be able to statistically quantify the degree of self-selection, but our model cannot capture institutional responses, such as changes in the education system, residential segregation, or other infrastructure.

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A Tables and figures

Table 4: Average Characteristics by Migration Status, Norway 1875

Variable	Non-Migrants	Migrants
	Norway	
Log-Income	5.543	5.608
	(0.512)	(0.470)
Age	27.323	31.710
	(7.471)	(4.876)
Urban Residence	0.204	0.272
	(0.403)	(0.445)
More than 3 Children	0.091	0.132
	(0.288)	(0.339)
N	35782	1840
	Mexico	
Age	40.554	36.497
	(10.048)	(8.317)
Education	4.562	3.736
	(2.333)	(1.386)
Log-Income	10.195	9.779
	(1.031)	(1.317)
N	4,680	98

Standard deviations in parentheses.

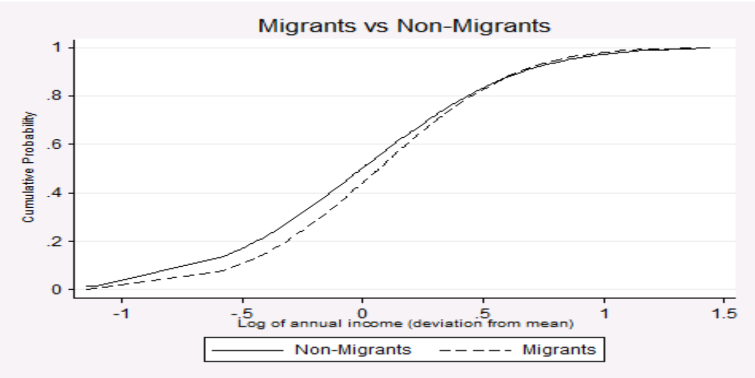
Table 5: OLS regression of Log-Income on Migration Status, Mexico 2002

	I	II	III	IV
	b/se	b/se	b/se	b/se
Migrant	–0.4780***	–0.2650***	–0.2239***	–0.4683***
	(0.0016)	(0.0015)	(0.0015)	(0.0047)
Age		0.0966***	0.0913***	0.0914***
		(0.0001)	(0.0001)	(0.0001)
Age Squared		–0.0011***	–0.0011***	–0.0011***
		(0.0000)	(0.0000)	(0.0000)
Education			0.0568***	0.0567***
			(0.0002)	(0.0002)
Years of Education x Migrant				0.0610***
				(0.0011)
Controls	No	Yes	Yes	Yes
N	5061	5061	5061	5061 '

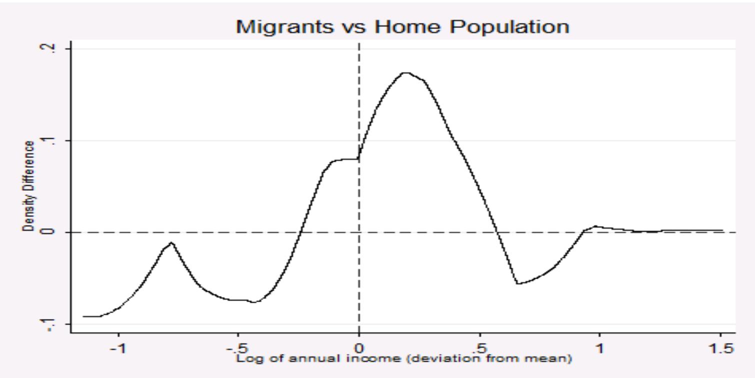
Robust standard errors in parenthesis.
All regressions have been weighted to account for the sampling procedures
Controls include a quadratic in age and state of redisence indicators

Table 6: Income distribution by decile, U.S.

U.S., 1880			
Decile	Natives	Norwegians	Other Migrants
1	0.180	0.111	0.060
2	0.005	0.002	0.009
3	0.005	0.004	0.012
4	0.368	0.445	0.215
5	0.007	0.004	0.026
6	0.155	0.149	0.206
7	0.166	0.179	0.286
8	0.035	0.053	0.071
9	0.034	0.025	0.041
10	0.045	0.030	0.075
U.S., 2002			
Decile	Natives	Mexicans	Other Migrants
1	0.017	0.042	0.024
2	0.035	0.143	0.059
3	0.062	0.240	0.101
4	0.129	0.240	0.154
5	0.205	0.170	0.189
6	0.244	0.109	0.183
7	0.157	0.037	0.127
8	0.099	0.014	0.104
9	0.035	0.004	0.037
10	0.017	0.001	0.020

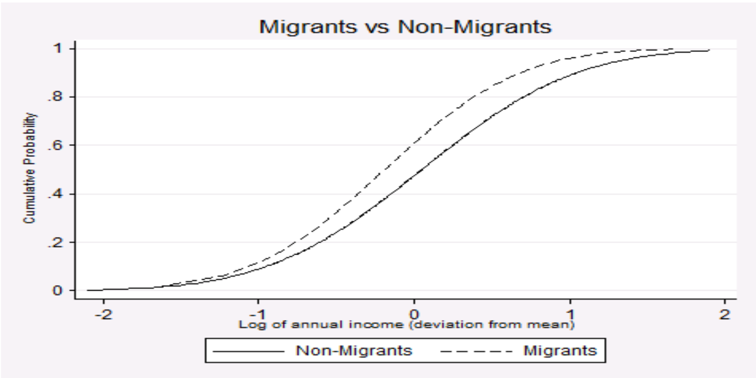


(a) Cumulative Distributions for Migrants and Non-Migrants

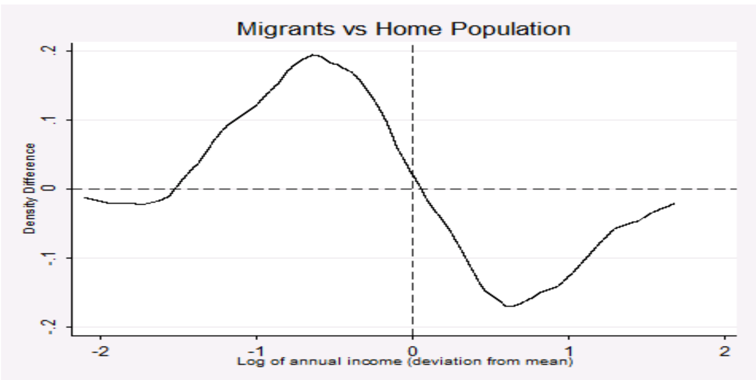


(b) Difference in Home Population and Migrants Distributions

Figure 6: Migrants, Non-Migrants and Home Population Earnings Distributions, Norway 1975.

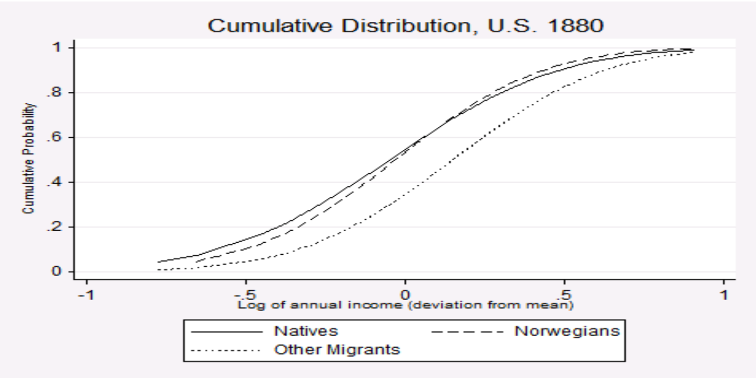


(a) Cumulative Distributions for Migrants and Non-Migrants

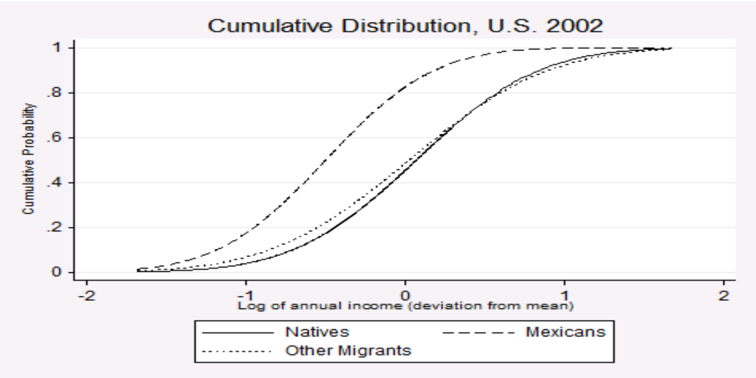


(b) Difference in Home Population and Migrants Distributions

Figure 7: Migrants, Non-Migrants and Home Population Earnings Distributions,, Mexico 2002.

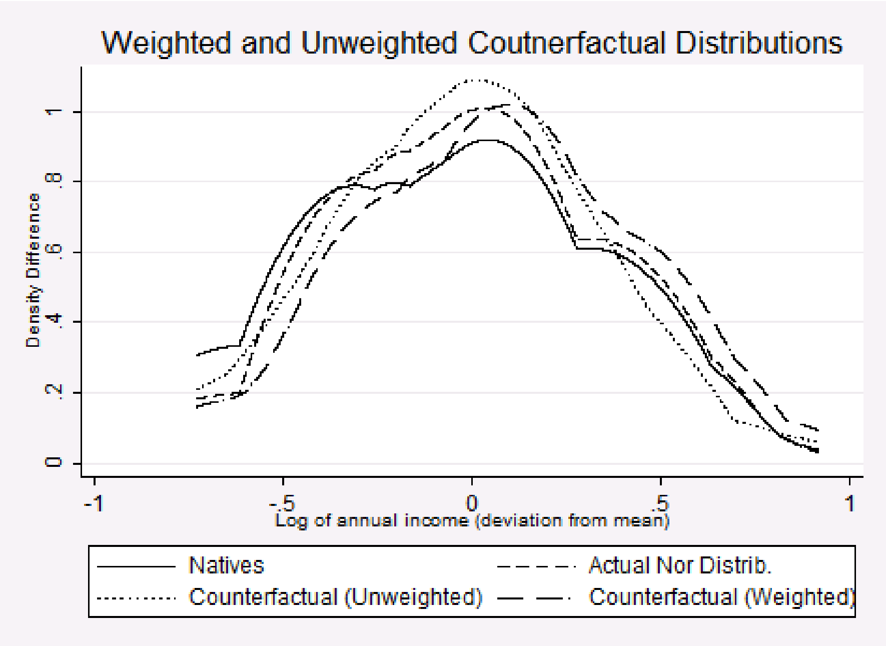


(a) Cumulative Distributions, U.S. 1880

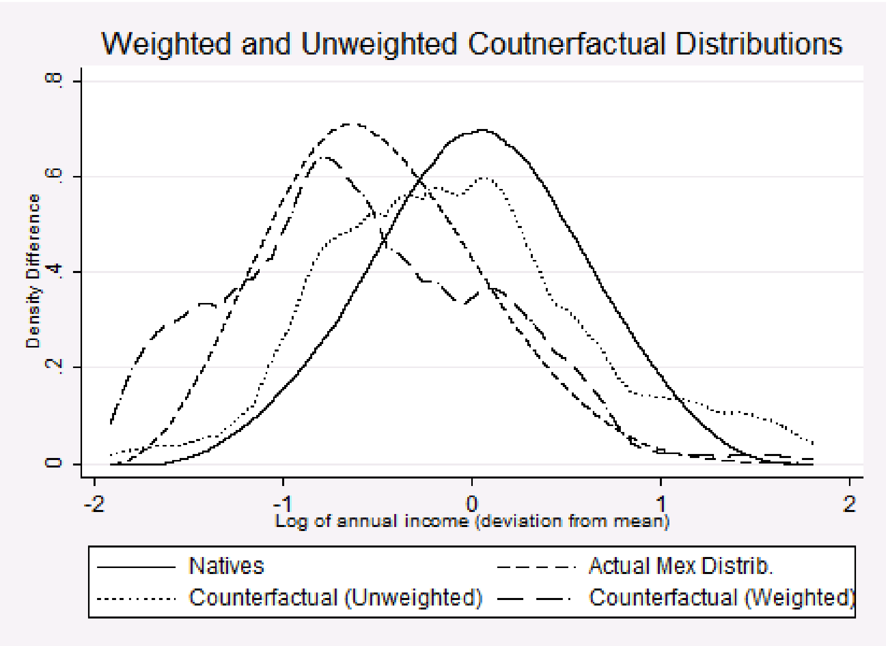


(b) Cumulative Distributions, U.S. 2002

Figure 8: Migrants and Natives Cumulative Earnings Distributions in the U.S., 1875 and 2002.



(a) Cumulative Distributions, U.S. 1880



(b) Distributions, U.S. 2002

Figure 9: Weighted and Unweighted Counterfactual distributions for Mexican Migrants in the U.S., 2002.

B Returns to skill

To compute the returns to skill for the traditional and the modern sector, we first assign occupations to sectors as described in Table 7.

Table 7: Occupational classification for traditional and complex sector.

	US 1880	**Norway 1880, US 2002**	**Mexico 2002**
	(1)	(2)	(3)
Traditional sector	Operative/Unskilled/Service	Operative/Unskilled/Service	Street sellers/service workers/workers
	Farm Operator/Supervisor	Farm Operator/Supervisor	operators/assistants
	Farm Laborer	Farm Laborer	Farm Operator/Supervisor
			Farm Laborer
Modern sector	Clerical/Sales	Clerical/Sales	Professional/Technical/Educ/Art
	Managerial/Official/Proprietor	Clerical/Sales	Manufacturing/craftsmen
	Professional/Technical	Clerical/Sales	Retailers
		Skilled Blue Collar (Craftsmen)	

The employment shares in sector Y given in Table 1 are calculated according to the following definitions: for the US in 1880 and 2002, and for Norway in 1880, according to the definition in column (2) of Table 7; for Mexico in 2002 according to the definition in column (3).

C Numerical procedure to find $\bar{Z}$

At the core of the general equilibrium model described in Section 3 lies the cutoff skill level $\bar{Z}$ between the traditional sector Y and the more advanced sector X. $\bar{Z}$ is determined endogenously, and depends on the structural parameters of the model and the skill distribution of the workforce. With a change in the migrant selection pattern, the skill distribution changes, which leads to a re-allocation of skill types between the two sectors. As shown by Iranzo & Peri (2009), $\bar{Z}$ is defined by the implicit function[9]

[9] Recall that g_Y and g_X are the returns to skill in the respective sector, β is the weight of good X in a CES utility function, σ is the elasticity of substitution between X and Y, θ is the elasticity of substitution between varieties of good X, M is the size of the native population in the receiving countries and the total population in the sending countries, F_X is the fixed cost of production in the advanced sector.

$$
\begin{aligned}
\Psi(\bar{Z}, g_Y, g_X, \beta, \sigma, \theta, M, F_X, G(Z)) &= \int_0^{\bar{Z}} \exp(g_Y Z) dG(Z) \\
&- \left(\frac{1-\beta}{\beta}\right)^{\theta} \left(\frac{\sigma}{\sigma-1}\right)^{\theta-1} \left(\frac{\sigma F_X}{M\Lambda}\right) \\
&\times \frac{\exp(\theta g_Y \bar{Z})}{\exp(\theta g_X \bar{Z})} \left(\int_{\bar{Z}}^1 \exp(g_X Z) dG(Z)\right)^{\frac{\sigma-\theta}{\sigma-1}} \\
&= 0. \qquad (4)
\end{aligned}
$$

For every country and every migration scenario, we compute a different value for $\bar{Z}$. Once we know $\bar{Z}$, we can re-calculate the unit costs C_X, which are the intercept of the equilibrium wage schedule for sector X shown in Figure 3. C_X, in turn, allows us to compute the equilibrium wage schedule using Equation (2), the average nominal wage using Equation (3), and the price index P_X.

In theory, the skill level Z is a continuous variable, with a continuous probability density function $g(Z)$. However, to recover $g(Z)$ from wage data, we face a trade-off between the bin size of the density function and the precision of the estimates. A smaller bin size translates into a smoother distribution, but it is estimated with lower precision. Making the bin size infinitely small, we would have a truly continuous function, but its estimation would be impossible. As a solution to this trade-off, we construct $g(Z)$ using 10 bins over the support of two standard deviations above and below the mean income. Restricting the distribution to these brackets around the mean cleans the distribution from the influence of outliers. Otherwise, there would be an extreme concentration of the probability mass around the mean, and very little mass in the tails.

Having a stepwise density function means that we may not find an exact solution to Equation (4), but rather an optimal $\bar{Z}$ that lies within one of the bins of the skill distribution. To find the exact value for $\bar{Z}$, we proceed as follows.

1. For every decile of the stepwise skill distribution, we compute the value of the implicit function $\Psi(\cdot)$, using the upper bound of every bin as $\bar{Z}$.

2. Using the function values for step 1, we approximate Ψ by a fourth-order polynomial, and determine the exact cutoff $\bar{Z}$ numerically, using $Z = 0.5$ as initial guess.

3. Let n be the bin that contains $\bar{Z}$. Using Equation (2), bins $1, ..., n-1$ are assigned the wage for sector Y, and $n+1, ..., 10$ the wage for sector X. The wage in bin

n is a weighted average between both wages. As an example, let $\bar{Z} = 0.37$, which means that it lies in the 4th decile of the skill distribution. The weight of wage Y in bin n would then be 0.7.

D GINI-COEFFICIENT

We calculate the Gini index based on real wages according to the formula

$$gini = 1 - \frac{\sum_{i=1}^{10} g(Z)(S_{i-1} + S_i)}{S_{10}}, \tag{5}$$

with $S_n = \sum_{i=1}^{n} g_i(Z)W_i(Z)$. $W_i(Z)$ is the wage of the i-th decile of the skill distribution. $g_i(Z)$ is the i-th decile of the skill distribution.