

# Labor Market Competition and the Assimilation of Immigrants\*

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*The gap between wages of immigrants at arrival and of comparable natives has widened substantially over the last decades, and the subsequent speed of convergence has slowed down. These facts lead to a pessimistic view regarding wage assimilation prospects of immigrants. This paper unravels an unexplored mechanism that can explain an important portion of these regularities: labor market competition. Because natives and immigrants may be imperfect substitutes in production, increasing immigrant inflows may exert stronger labor market competition on previous cohorts of immigrants than on natives, contributing to widening the gap. We quantify the importance of this mechanism by using a simple model that accounts for the main features of the literatures of wage impacts of immigration and wage assimilation. Our simulations suggest that, if competition and (education and national origin) composition effects are netted out, immigrant cohorts are more positively selected in recent decades, and that these differences are wiped out after 10 years, which implies a lower relative wage growth for recent cohorts. We speculate that this could be the result of more selective immigration policies and/or increasing globalization among other factors.*

**Keywords:** Immigrant Assimilation, Labor Market Competition, Cohort sizes, Imperfect Substitution, General and Specific Skills

**JEL Codes:** J21, J22, J31, J61

## I. Introduction

The Syrian Refugee Crisis and the rise in xenophobic movements around the world have renewed the interest for understanding the process of assimilation of immigrants into the receiving society. The capacity of immigrants to acquire country-specific skills such as language and business culture is a crucial determinant of their productivity in the labor market. Moreover, integration has been shown to have a positive effect on

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natives' attitudes towards immigration.<sup>1</sup> Therefore, understanding the process by which immigrants assimilate into the labor market is essential for immigration policy design.

It is well documented that wages of immigrants and the number of years they have spent in the U.S. are positively correlated. However, the extent to which this correlation can be attributed to immigrant assimilation has been the subject of a long debate (see Borjas, 1999, 2014 and Cadena, Duncan and Trejo, 2015 for surveys). Seminal work by Chiswick (1978) interpreted this correlation exclusively as evidence of speedy labor market assimilation. However, Borjas (1985) noted that a large fraction of it can be spurious, as a result of the declining productivity of recent immigrant cohorts. Other papers have shown, as well, that the speed of convergence of immigrant wages towards those of natives have decreased for recent immigrant cohorts (Smith, 2006; Borjas and Friedberg, 2009; Borjas, 2015). Overall, these facts present a pessimistic view regarding wage assimilation prospects of immigrants.

In this paper we show that an important fraction of these empirical regularities can be explained by imperfect substitutability between natives and immigrants, increasing sizes of immigrant inflows, and labor market competition. Observationally equivalent natives and immigrants are typically employed in different occupations, which makes them imperfect substitutes in production (Peri and Sparber, 2009; Ottaviano and Peri, 2012; Manacorda, Manning and Wadsworth, 2012; Lull, 2018a). Immigrants have also been shown to downgrade at entry (Dustmann, Frattini and Preston, 2013). As a result of all this, recent immigrants are exposed to stronger labor market competition by the increasingly larger entry cohorts. This increasing competition can explain a substantial fraction of the increase in the wage gap at entry, and also has important implications for the speed of wage convergence observed in recent years. This mechanism provides a better understanding of the observed patterns for different cohorts of immigrants. Furthermore, it is particularly relevant for policy, as it implies that immigration policies that determine the size and composition of immigrant inflows have additional unintended effects on the extent of immigrant wage assimilation.

Our analysis provides a decomposition of the observed regularities into different mechanisms, filtering the data through the lens of a simple production framework. In our framework, natives and immigrants supply general skills, which are portable across countries, and skills that are specific to the United States. At entry, immigrants are endowed with the same amount of general skills than observationally equivalent natives, but only with a fraction of their U.S.-specific skill units. As they spend time in the United States, they accumulate specific skill units at a faster rate than natives, which we interpret as the skill assimilation process. General and specific skills are aggregated by a Constant Elasticity of Substitution (CES) technology, which allows for imperfect substitutability between them. Consistent with a competitive equilibrium, workers are paid their marginal

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<sup>1</sup> See, for example, Hatton and Leigh (2011).

product. Thus, relative skill prices depend on the relative supplies of these two types of skills. Since immigrants disproportionately supply general skills, increasing sizes of immigrant inflows shift these relative prices in favor of specific skills. As a result, the wage gap between natives and immigrants, especially at arrival, widens. On the other hand, nearly fully assimilated immigrants are almost perfect substitutes to natives, and, therefore, the mechanism also affects relative wage growth. Finally, a third mechanism is the dynamic nature of immigrant cohort size growth, which makes all cohorts to be more affected at later assimilation stages, thus affecting as well the observed relative wage growth.

The model accounts for the main features of the literature on wage impacts of immigration and on wage assimilation. In particular, it allows for imperfect substitutability between natives and immigrants (Peri and Sparber, 2009; Ottaviano and Peri, 2012; Manacorda, Manning and Wadsworth, 2012; Lull, 2018a), immigrant downgrading at entry (Dustmann, Frattini and Preston, 2013), it is, to some extent, consistent with different CES aggregation frameworks like the ones popularized in the immigration literature by Borjas (2003) and Ottaviano and Peri (2012), and it (approximately) nests the standard regressions estimated in the wage assimilation literature (e.g. Borjas, 1985, 1995, 2015) as the special case in which there are no competition effects.

We fit our model on individual wage data from the U.S. Census and the American Community Survey (ACS) over the period 1970 to 2010 by Non-Linear Least Squares (NLS). Using our estimated model, we decompose the evolution of the initial wage gap and relative wage growth into three different channels: the competition effect, a composition effect driven by changes in the education and country of origin distribution, and the residual, which we interpret as unobservable skills and skill assimilation respectively for the initial wage gap and the relative wage growth. To analyze the competition effect, we explore different counterfactual scenarios, shutting down imperfect substitutability between general and specific skills, and also comparing our baseline predictions with several counterfactual scenarios with different evolution of cohort sizes.

Results show an important role for competition effects. In particular, they explain from 5 to 20 percent of the widening of the gap for the cohorts that arrived in the 1970s (relative to those arrived before), 19 to 48 percent for the 1980s cohorts, and from 50 to 100 percent for the cohorts arrived after 1990. Likewise, they can explain 0.5 to 2 percentage points of the observed relative wage growth over the first 10 years, consistently across cohorts. Importantly, after netting out these competition effects and the composition effects based on education and national origin, the patterns of wage assimilation look remarkably different to those directly observed in the data. In particular, recent immigrant cohorts appear to be more *positively* (instead of negatively) selected than older cohorts, especially those arrived after 1990. These differences disappear after 10 years, which explains why the rate of relative wage convergence has decreased in recent decades. Overall, the speed of skill assimilation is estimated to be arguably faster than

what the raw data shows: in the majority of our scenarios, a high school dropout Mexican worker would close more than two thirds of the initial wage gap in the first 15 years. We speculate that these results are consistent with a more selective immigration policy and a more widespread accumulation of U.S.-specific skills (for example, knowledge of English or business culture) outside of American borders as a result of globalization.

This paper contributes to the large literature that studies the wage assimilation of immigrants. Beginning with Chiswick (1978), this literature has typically studied the problem through the lens of relative wage convergence. LaLonde and Topel (1992) define assimilation as the process whereby “between two observationally equivalent persons, the one with greater time in the United States typically earns more” (p. 75). Chiswick (1978) documents, in a cross-sectional analysis, a strong and positive correlation between wages of immigrants as the time they spend in the United States. Subsequent work by Borjas (1985, 1995, 2015) shows that taking into account the changes in cohort quality leads to significantly flatter relative wage convergence. A substantial body of research links the decrease in skills of arriving cohorts and the drastic change in national origin composition of immigrants (e.g. Borjas, 1987, 1992; Jasso, Rosenzweig and Smith, 2000; Card, 2005).<sup>2</sup> Our paper shows that an important part of these regularities can be explained by increasing cohort sizes, based on our labor market competition channel.

Some recent studies in assimilation use longitudinal datasets, which allow them to completely remove unobserved heterogeneity in skills and account for selective return migration (Hu, 2000; Duleep and Dowhan, 2002; Lubotsky, 2007, 2011; Abramitzky, Boustan and Eriksson, 2014). Furthermore, Beaman (2012) relates these labor market dynamics with networks using exogenous variation from refugee immigrants resettled in the United States. We abstract from these two mechanisms because of data limitations.

The labor market competition channel introduced in this paper is also closely related to the large literature that analyzes wage effects of immigration. This literature is long-standing and controversial. Friedberg and Hunt (1995), Borjas (1999), Borjas (1999), Card (2005), Kerr and Kerr (2011), Cadena, Duncan and Trejo (2015), Dustmann, Schönberg and Stuhler (2016) provide extensive surveys. Different papers in this literature exploit different sources of variation, reaching different conclusions. Some papers exploit variation from natural experiments (e.g., Card, 1990; Glitz, 2012; Dustmann, Schönberg and Stuhler, 2017) or instrumental variables (e.g., Altonji and Card, 1991; Card, 2005; Monràs, 2015) in spatial correlations comparisons. Others exploit variation across education-experience cells and over time (e.g., Borjas, 2003; Llull, 2018b). Recent papers follow

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<sup>2</sup> A large number of papers have estimated some version of Borjas (1995) for different countries. For example, Antecol, Kuhn and Trejo (2006) estimate assimilation patterns for Australia, Canada, and the United States, Baker and Benjamin (1994) estimates them for Canada, Dustmann (1993) for Germany, Friedberg (2000) and Eckstein and Weiss (2004) for Israel, Edin, LaLonde and Åslund (2000) for Sweden, Bell (1997) for the United Kingdom, and Kossoudji (1989), Schoeni (1997), and Bratsberg and Ragan (2002) for the United States, among others.

more structural approaches, either relying on simulations based on structurally estimated production functions (e.g., Borjas, 2003; Ottaviano and Peri, 2012; Manacorda, Manning and Wadsworth, 2012), search and matching models (Chassamboulli and Peri, 2015; Battisti, Felbermayr, Peri and Poutvaara, 2018; Albert, 2019), or equilibrium settings (Llull, 2018a; Piyapromdee, 2019). Different approaches typically deliver different results on the overall effect of immigration, but there is some agreement that workers that are more similar to immigrants are more negatively affected than those that are different. Some groups of native workers are often estimated to benefit from immigration through their relative complementarity with immigrants. Peri and Sparber (2009), Ottaviano and Peri (2012), and Manacorda, Manning and Wadsworth (2012) provide evidence of the importance of imperfect elasticity of substitution between natives and immigrants in quantifying wage effects of immigration. Llull (2018a) generates comparable levels of imperfect substitutability by endogenously modeling occupation decisions, even when natives and immigrants are perfect substitutes within a given occupation. Dustmann, Frattini and Preston (2013) show that immigrants downgrade at entry and, therefore, do not compete with observationally equivalent natives, but with the workers employed in the same jobs they work. In our model, imperfect substitutability, partly driven by downgrading, is a fundamental element for our labor market competition mechanism to operate.

Finally, this paper is also related to a broader literature in economics that studies the effects of changing demographic structures on the dynamics of wages of imperfectly substitutable workers. Starting with Katz and Murphy (1992), many papers have used CES frameworks to quantify how the evolution of socio-demographic characteristics can explain the evolution of relative wages in recent decades. Krusell, Ohanian, Ríos-Rull and Violante (2000) estimate a nested CES production function to show that capital-skill complementarity and the decreasing prices of equipment capital can explain most of the increase in the college-high school wage gap. Card and Lemieux (2001) use another nested CES technology to analyze how much changes in labor supply across age groups with the same education can explain this increase. Jeong, Kim and Manovskii (2015) use a framework that is similar to Katz and Murphy (1992) to quantify the extent to which demographic changes can account for the changes in returns to experience in recent decades, the differential dynamics of returns to experience across education groups, and the increase in the college-high school wage gap. Our analysis follows a similar approach to uncover the mechanisms behind the evolution of relative wages of immigrants that arrived in different cohorts relative to natives.

The rest of the paper is organized as follows. Section II provides a brief description of our data and some regressions that describe the relationship between the dynamics of relative wages and the size of immigrant inflows. Section III presents our modeling framework. Section IV discusses identification and estimation of the model. Section V presents the baseline estimation results and checks the goodness of our model in fitting

the observed patterns in the data. In Section VI we present simulation results and our decomposition exercise. Finally, Section VII provides some analysis of the robustness of our results to different specifications, before we conclude in Section VIII.

## II. Data and Descriptive Evidence

In this section, we provide a brief description our data and sample, and provide some regressions that describe the main patterns of assimilation established in the literature. Our goal in the sections below is to investigate the extent to which our labor market competition mechanism can explain these patterns.

### A. Data

Our empirical analysis is based on U.S. Census data for the years 1970, 1980, 1990, and 2000, which we combine with pooled observations from the American Community Survey (ACS) for the years 2009-2011. All data are downloaded from the Integrated Public Use Microdata Series (IPUMS-USA, Ruggles, Flood, Goeken, Grover, Meyer, Pacas and Sobek, 2018). Our main sample includes males aged 25 to 64 who are not self-employed, do not live in group quarters, are not enrolled in school (except for 1970), work in the civilian sector, and report positive hours of work and earnings. We drop immigrants with no information on their country of birth or year of arrival in the United States. Further details on the variable definitions are provided in Appendix A.

Table 1 reports descriptive statistics on the size and composition of different immigrant arrival cohorts, which we aggregate by decade. Cohorts sizes increased steadily over the time period considered, with the 1960s cohort comprising around 500 thousand individuals, the 1980s cohort 1.7 million individuals and the 2000s cohort 3.1 million individuals. This substantial increase in the size of the immigrant inflows was accompanied by an important shift in their ethnic and educational composition. In the 1960s, most immigrants originated from Western source countries (37.9 percent) and relatively few from Mexico (9.7 percent) and Asia (14.8 percent). Over the following decades, this pattern reversed, with the share of migrants from Western countries decreasing to 7.2 percent and the share from Mexico and Asia increasing to 29.3 and 27.5 percent, respectively. At the same time, the level of formal education of the new cohorts of immigrants improved notably, especially since the 1980s, with the share of high school dropouts decreasing from 46.1 percent in the 1960s to 26.8 percent in the 2000s, and the share of college-educated immigrants increasing from 24.1 percent in the 1960s to 34.7 percent in the 2000s.

As shown in Table C1 Appendix C, the accelerating inflow of new immigrants led to an increase of the immigrant share in the population from 3.5 percent in 1970 to 15.6 percent in 2010. Despite the improvement in educational attainment across subsequent arrival cohorts, immigrants are on average significantly less educated than natives, with a high school dropout share of 27.4 percent compared to only 5.1 percent among the



TABLE 1—DESCRIPTIVE STATISTICS OF IMMIGRANT COHORTS

	Cohort of entry:				
	1960-69	1970-79	1980-89	1990-99	2000-09
Share of population (%)	1.6	2.2	3.5	4.7	5.4
Cohort size (millions)	0.5	0.9	1.7	2.6	3.1
Age	38.3	36.8	35.9	36.2	37.0
Hourly wage	19.1	18.4	15.8	17.4	15.5
HS dropouts (%)	46.1	41.3	29.5	27.7	26.8
HS graduates (%)	19.1	19.2	22.6	27.2	26.9
Some college (%)	10.6	11.3	18.6	12.0	11.6
College graduates (%)	24.1	28.3	29.3	33.1	34.7
Mexico (%)	9.7	23.5	20.9	28.1	29.3
Other Latin America (%)	27.9	19.4	25.4	20.6	25.0
Western countries (%)	37.9	18.0	10.6	9.9	7.2
Asia (%)	14.8	31.4	34.5	28.5	27.5
Other (%)	9.7	7.7	8.5	13.0	11.0

*Note:* The statistics are based on the sample of male immigrants aged 25-64 reporting positive income (not living in group quarters) that entered the United States during the respective time intervals, measured in the first Census year following the arrival. Observations are weighted by the personal weights obtained from IPUMS, rescaled by annual hours worked.

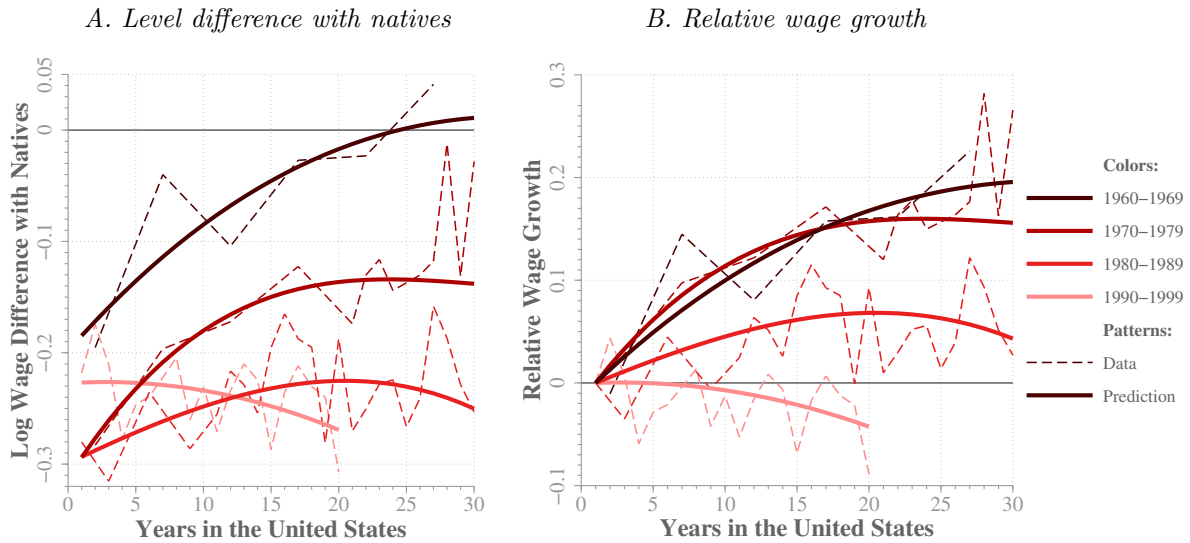
native population in 2010. The secular changes in educational attainment and country of origin composition are likely to explain at least part of the observed changes in immigrant assimilation profiles shown below (for example, see Figure 1). In our empirical analysis, we quantify the contribution of these composition changes and compare it to the contribution of labor market equilibrium effects due to the increase in immigrant cohort sizes.

### *B. Descriptive Evidence on Assimilation Patterns over Recent Decades*

Most of the economics literature on immigrant assimilation has focused on the extent to which immigrants' wages converge to those of observationally equivalent natives as immigrants spent time in the host country. A first cross-sectional approach estimated in the early literature is to regress individual wages on a flexible function of potential experience and some control variables, and additionally include, for immigrants, a flexible function of years since migration (e.g. see Chiswick, 1978). As first noted by Borjas (1985), however, the estimated relationship between years since migration and the relative wage gap between immigrants and natives does not only reflect wage assimilation if the skills of immigrants are systematically changing across cohorts. Relying on multiple cross-sections, the problem can be resolved by including cohort fixed effects in the regression model. Following the latter approach, which is the current standard in the literature, we motivate our analysis by showing how immigrant wage assimilation profiles have changed over time and how the initial wage gaps and subsequent convergence rates are correlated with the size of immigrant inflows. The regressions are estimated on decennial census data for the period 1970 to 2010.

In Figure 1, we show two sets of results. The dashed lines are obtained from year-by-year regressions of log wages on a third order polynomial in age and dummies for

FIGURE 1. WAGE GAP BETWEEN NATIVES AND IMMIGRANTS AND YEARS IN THE U.S.



*Note:* The figure shows the prediction of the wage gap between natives and immigrants of different cohorts as they spend time in the United States. The dashed lines represent the raw data, which is the result from year-by-year regressions of log wages on a third order polynomial in age and dummies for the number of years since migration. Solid lines represent fitted values of a regression that includes cohort and year dummies, a third order polynomial in age interacted with year dummies, and a (up to a) third order polynomial in years since migration interacted by cohort dummies (in particular, we include the first term of the polynomial for all cohorts, the second term for all cohorts that arrived before year 2000, and the third order term for all cohorts that arrived before 1990). Cohorts are grouped in the following way: before 1960, 1960-1969, 1970-1979, 1980-1989, 1990-1999, and after 2000. Colors represent cohorts, and shapes represent data or regression predictions as indicated in the legend.

years since migration, thus reflecting the raw data. The solid lines are obtained from a single regression of log wages on year fixed effects and their interaction with a third order polynomial in age, and cohort-of-entry fixed effects and their interaction with a third order polynomial in years since migration.<sup>3</sup> While Figure 1A shows the estimated wage gaps and their evolution over time and across cohorts, Figure 1B highlights the relative wage growth, normalizing the initial wage gaps of each cohort to zero.<sup>4</sup>

Figure 1 shows two major changes in immigrants' wage assimilation profiles, already established by the literature. First, the initial wage gap between newly-arriving immigrants and natives has widened over time, at least until the 1990s. While the 1960s cohort arrived with an initial wage gap of less than 20 log points and managed to fully assimilate within 25 years, the 1970s and 1980s arrival cohorts faced a substantially larger initial wage gap, of around 30 log points. For the 1990s cohort, this gap declined again to around 22 log points. The second change is the speed of wage convergence, which has decreased substantially for more recent cohorts, to the point that the 1990s cohort no longer shows any wage assimilation after arrival.

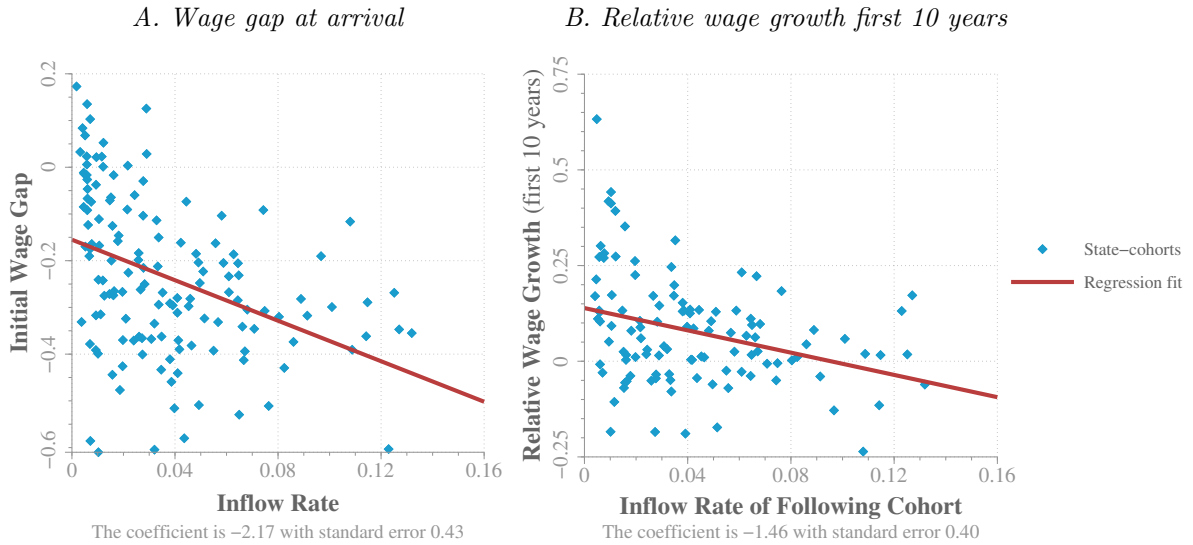
Our central hypothesis is that the changing wage assimilation patterns across cohorts

<sup>3</sup> The first term of the polynomial in years since migration is interacted with all cohort dummies, the second one is interacted with all cohort dummies that entered before year 2000, and the third term is interacted with all dummies for cohorts that entered before 1990. Cohorts are grouped in 10-year intervals. The pre-1960 and post-2000 cohorts are not plotted but also included in the regression.

<sup>4</sup> For the first two cohorts the first data point refers to individuals who have spent two years in the United States. Thus, we normalize the curves to the second-year prediction.



FIGURE 2. COHORT SIZE, INITIAL WAGE GAP, AND RELATIVE WAGE GROWTH



*Note:* This figure plots initial wage gap (left) and relative wage growth over the first 10 years (right) for state-cohort cells against the size of own and following immigrant cohorts, respectively. Initial gap and wage growth are computed based on state-by-state regressions that include cohort and year dummies, a third order polynomial in age interacted with year dummies, and a (up to a) third order polynomial in years since migration interacted by cohort dummies (we include only the linear term for the last cohort, and a quadratic for the one that arrived in the 1990s). Cohorts are grouped in the following way: before 1960, 1960-1969, 1970-1979, 1980-1989, 1990-1999, and after 2000. The initial wage gap is measured as the state-specific cohort fixed effect and the relative wage growth is the change in the wage gap after 10 years, which is calculated based on the polynomial in years since migration interacted with cohort dummies. Immigrant inflows are computed as the state population of the respective cohort divided by the native population in the state in the first census year the cohort is observed. The cohort that arrived before 1960 is not included in the plots. States with less than 50 immigrants in any of the census years are excluded from the sample. Dots represent state-cohorts and lines represent linear regression fit.

are partially driven by changes in the relative supply of different skills due to the growing immigrant inflows into the United States since the 1960s. To provide some raw evidence, Figure 2 relates the predicted initial wage gap (left figure) and the relative wage growth over the first ten years in the United States (right figure) to the size of the different immigrant arrival cohorts, exploiting variation at the state-cohort level. The initial gaps and relative growth rates are predicted from regressions analogous to those underlying the solid lines in Figure 1 but estimated for each state separately (excluding states with less than 50 immigrants in any of the censuses). The figure shows that correlations align with our hypotheses. Larger immigrant arrival cohorts are characterized by a more pronounced initial wage gap, as our framework unambiguously predicts. As we discuss below, the predicted effect on wage growth is ambiguous. Figure 1B shows a negative correlation between the sizes of immigrant inflows and the relative wage growth thereafter. In the next section, we propose a simple framework that highlight the importance of labor market competition as a driver of relative wage profiles.

### III. Theoretical Framework

We model the relationship between labor market equilibrium effects and immigrants' wage assimilation profiles with a simple production framework that combines two types of imperfectly substitutable skills, both paid at a rate equal to their marginal product. In-

dividuals supply skills that are “general” (or portable) across countries and skills that are host country “specific”, which include language skills but also more broadly the ability to successfully navigate the local institutional and cultural environment. We normalize the supply of each of these skills to be equal to one for a native who just dropped out of high school. Individual skill supplies are shifted by a skill index that is a function of a set of observable characteristics such as education and age. Human capital accumulates mechanically through learning by doing on the job. When arriving in the host country, immigrants supply the same amount of general skills as comparable natives but only a fraction of their country-specific skills. This fraction then evolves as they spend time in the country.

Let  $G_t$  denote the aggregate supply of general skill units and  $S_t$  the aggregate supply of specific skill units in year  $t$ . Output  $Y_t$  is produced according to the following constant returns to scale production technology:

$$Y_t = A_t \left( G_t^{\frac{\sigma-1}{\sigma}} + S_t^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \quad (1)$$

where  $\sigma$  denotes the elasticity of substitution between general and specific skills, and  $A_t$  denotes total factor productivity.<sup>5</sup> The aggregate supplies of skills are obtained by summing up the individual supplies of all workers in the economy. The marginal products and, hence, the rates of return to general and specific skills  $r_{Gt}$  and  $r_{St}$  are equal to:

$$r_{Gt} = A_t \left( \frac{Y_t}{A_t G_t} \right)^{\frac{1}{\sigma}} \quad \text{and} \quad r_{St} = A_t \left( \frac{Y_t}{A_t S_t} \right)^{\frac{1}{\sigma}}. \quad (2)$$

As noted above, recent high school dropouts (the base group) supply one general skill unit and a fraction  $s$  of a specific skill unit, with  $s = 1$  for natives. Let  $n \equiv \mathbb{1}\{\text{native}\}$  denote an indicator variable that equals one if the individual is a native and zero otherwise. For immigrants ( $n = 0$ ), the fraction  $s$  depends on the number of years spent in the host country  $y$ , national origin  $k$ , cohort of entry  $j$ , education level  $e(E)$ , where  $E$  denotes years of education, and potential experience at the time of arrival  $x - y$ , where  $x$  denotes current potential experience (age minus education).<sup>6</sup> In particular:

$$s(n, y, k, j, E, x) \equiv \begin{cases} 1 & \text{if } n = 1 \\ \theta_{0k} + \sum_{\ell=1}^3 \theta_{1k\ell} y^\ell + \theta_{2e(E)} + \sum_{\ell=1}^3 \theta_{3e(E)\ell} y^\ell & \text{if } n = 0 \\ + \sum_{\ell=1}^3 \theta_{4\ell} (x - y)^\ell + \theta_{5j} + \sum_{\ell=1}^3 \theta_{6j\ell} y^\ell & \end{cases} \quad (3)$$

where we allow the skill accumulation process of  $s$  to vary across different national origin groups ( $\theta_{1k\ell}$ ), education groups ( $\theta_{3e(E)\ell}$ ) and cohorts of entry ( $\theta_{6j\ell}$ ). General and specific

<sup>5</sup> An alternative specification that allows for changing over-time relative importance of  $G_t$  and  $S_t$  is also estimated below as a robustness check.

<sup>6</sup> In practice, since we focus on the sample of individuals aged 25 and above, we define potential experience so that it is zero at age 25 if the individual dropped out from school at any time before that age.

skills are shifted by a skill index defined as:

$$h_t(E, x) \equiv \exp \left( \eta_{0e(E)t} + \eta_{1t}E + \sum_{i=1}^3 \eta_{2it}x^i \right). \quad (4)$$

Workers are paid according to the combination of skill units they supply to the market, so that wages are given by:

$$w_t(n, y, k, j, E, x) = [r_{Gt} + r_{St}s(n, y, k, j, E, x)] h_t(E, x). \quad (5)$$

Given the equilibrium rates of return to general and specific skills in Equation (2), the wages of immigrant workers relative to observationally equivalent native workers as a function of  $y$  can be expressed as:

$$\begin{aligned} \frac{w_t(0, y, k, j, E, x)}{w_t(1, \cdot, \cdot, \cdot, E, x)} &= \frac{r_{Gt} + r_{St}s(n, y, k, j, E, x)}{r_{Gt} + r_{St}} \\ &= \frac{1 + s(n, y, k, j, E, x)(G_t/S_t)^{\frac{1}{\sigma}}}{1 + (G_t/S_t)^{\frac{1}{\sigma}}}. \end{aligned} \quad (6)$$

Equation (6) serves as the basis of our estimation and counterfactual simulation exercises. It identifies the two key drivers of the wage assimilation profiles of immigrants. First, the rate at which  $s(n, y, k, j, E, x)$  evolves over time spent in the host country ( $y$ ) which reflects the skill assimilation process of immigrant workers. Second, the competition effect due to changing relative skill supplies ( $G_t/S_t$ ), which plays a role as long as general and specific skills are imperfect substitutes in the production process ( $\sigma < \infty$ ) and immigrants differ from natives in terms of the skill bundle they supply.

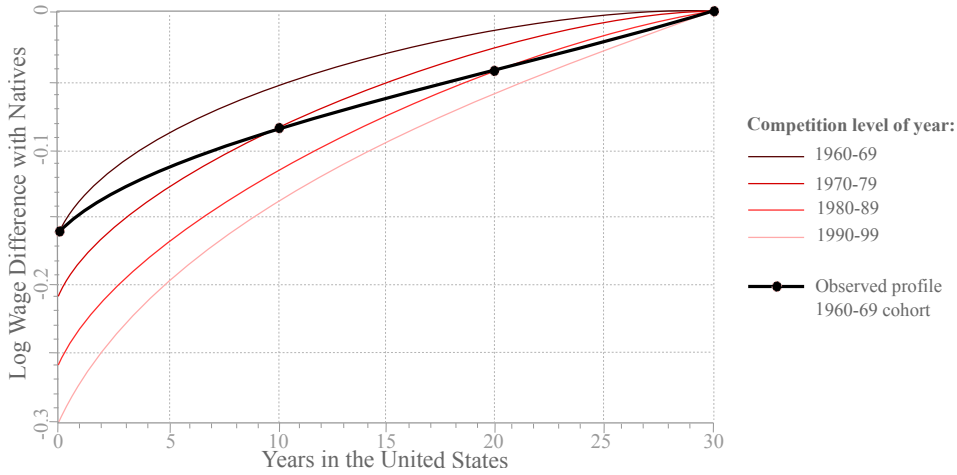
Consider how changes in the size of immigrant inflows affect relative wage profiles, holding the skill accumulation process constant. Since immigrants disproportionately supply general skills upon arrival (when typically  $s \ll 1$ ), a larger immigrant inflow will increase  $G_t/S_t$  by more and thus widen the wage gap relative to natives:

$$\frac{d \frac{w_t(0, y, k, j, E, x)}{w_t(1, \cdot, \cdot, \cdot, E, x)}}{d[G_t/S_t]} = \frac{[s(n, y, k, j, E, x) - 1](G_t/S_t)^{\frac{1-\sigma}{\sigma}}}{\sigma \left[1 + (G_t/S_t)^{\frac{1}{\sigma}}\right]^2} \leq 0. \quad (7)$$

Therefore, the larger a new immigrant arrival cohort, the larger will be the initial wage gap it faces relative to natives, *ceteris paribus*. In addition, a larger immigrant arrival cohort will also widen the wage gap of earlier cohorts of immigrants relative to natives, especially if those cohorts arrived relatively recently. This is because more recent immigrants have less specific skills than older cohorts, which have already accumulated specific skills in the host country labor market. Intuitively, closer arrival cohorts are more similar in terms of the skill bundles they supply, and therefore more substitutable in the labor market.

Larger immigrant cohorts also affect the speed of relative wage convergence as immigrants spend time in the United States. Consider the skill accumulation process  $s$ , which

FIGURE 3. DYNAMIC COMPETITION EFFECT: AN EXAMPLE



*Note:* The figure plots hypothetical convergence paths for different levels of competition when the size of the immigrant inflows increase across arrival cohorts, and the implied assimilation curve we would observe in the data for a cohort that arrived in 1960s.

determines the relative wage convergence of a given immigrant arrival cohort as  $y$  changes. Now suppose that aggregate skill supplies increase permanently, for instance because of an increase in the steady-state inflow rate of new immigrants. For a given arrival cohort, such a permanent change in aggregate skill supplies will have a larger (negative) impact in the early years after arrival than in the later years. In particular:

$$\frac{d}{dy} \left( \frac{d \frac{w_t(0,y,k,j,E,x)}{w_t(1,y,\dots,E,x)}}{d[G_t/S_t]} \right) = \frac{ds(n,y,k,j,E,x)}{dy} \frac{(G_t/S_t)^{\frac{1-\sigma}{\sigma}}}{\sigma \left[ 1 + (G_t/S_t)^{\frac{1}{\sigma}} \right]^2} \geq 0, \quad (8)$$

which implies that the slope of the wage assimilation profile and therefore the speed of wage convergence increases for this cohort.

There is another mechanism by which the increasing sizes of immigrant cohorts can decrease the observed speed of relative wage convergence for immigrants. If the sizes of immigrant cohorts steadily increase over time, unlike in the one-time permanent increase analyzed in (8), the positive impact on the slope of the convergence curve is combined with a continuous downward shift of the assimilation curve as described in (7), which can offset the positive effect on the slope. We call this effect the dynamic competition effect, and we also analyze it in our counterfactuals. To gain intuition about the nature of this dynamic effect we plot an example in Figure 3. In the example, the size of immigrant cohorts increase over time, which is observed in the increasing the gap and slope observed for the different assimilation curves. If each of these increases were a once and for all change, the observed speed of assimilation would increase (the slope of lighter lines is larger than the one of darker lines), even though the starting point would be lower. However, if the sizes of immigrant cohorts are growing over time, the pattern that we would observe is the black thicker line (circles), which implies a slower speed of wage convergence.

Our framework is consistent with the most relevant aspects of the literatures on the wage impact of immigration and immigrant wage assimilation. Peri and Sparber (2009),

Ottaviano and Peri (2012) and Llull (2018a) argue that natives and immigrants are imperfect substitutes in production because they work in different occupations. According to Peri and Sparber (2009), immigrants have comparative advantage in occupations that are intensive in the use of manual tasks while natives specialize in language-intensive tasks. Through the lens of our model, manual tasks would be intensive in general skills (tasks like nailing, building or gardening are quite similar across countries) whereas language-intensive tasks require host country specific skills (such as language fluency). In the analysis below, we explicitly link our estimate of the elasticity of substitution between general and specific skills ( $\sigma$ ) to the elasticity of substitution between natives and immigrants that has been estimated in the literature.

More generally, Equation (1) looks somewhat different to the standard nested CES production function popularized by Borjas (2003), Ottaviano and Peri (2012) and Manacorda, Manning and Wadsworth (2012). However, our framework can be generalized by further dividing labor markets into different skill cells as long as the lowest level of the nesting structure is defined in terms of general vs. specific skills within a given cell, similarly to Ottaviano and Peri (2012).

Dustmann, Frattini and Preston (2013) discuss the importance of downgrading of immigrants at the time of arrival in the host country. A surgeon from Venezuela is unlikely to be able to practice as such in the United States if she does not speak English sufficiently well. As a result, she will need to find a different, often lower paying, job in the early phase after arrival until she attains the required English language proficiency that allows her to transition to higher paying jobs. Our model captures such initial downgrading by allowing immigrants to lack specific skills at the time of arrival ( $s \ll 1$ ) and then accumulate them as they spend time in the United States. To account for the heterogeneity across immigrants groups, we allow this downgrading to vary with immigrants' observed characteristics, including country of origin and education.

Finally, our model nests standard wage assimilation regression that has been estimated in most of the existing literature (e.g. Borjas, 1985, 1995, 2015) as a special case. In particular, under perfect substitutability between immigrants and natives ( $\sigma = \infty$ ), log wages in our framework are given by:

$$\begin{aligned} \ln w_t(n, y, k, j, E, x) &= \ln A_t + \ln[1 + s(n, y, k, j, E, x)] + \ln h_t(E, x) \\ &\approx \delta_t + \eta_{0e(E)t} + \eta_{1t}E + \sum_{\ell=1}^3 \eta_{2\ell t}x^\ell + (1 - n) \left[ \begin{aligned} &\theta_{0k} + \sum_{\ell=1}^3 \theta_{1k\ell}y^\ell + \theta_{2e(E)} + \sum_{\ell=1}^3 \theta_{3e\ell}y^\ell \\ &+ \sum_{\ell=1}^3 \theta_{4\ell}(x - y)^\ell + \theta_{5j} + \sum_{\ell=1}^3 \theta_{6j\ell}y^\ell \end{aligned} \right], \end{aligned} \quad (9)$$

where, in the last line, we make use of the approximation  $\ln(1 + s) \approx s$  and define  $\delta_t \equiv \ln A_t + n \ln(2)$ . This expression corresponds to the standard wage assimilation regression in the literature. Our framework can thus be viewed as a generalization of the standard model which allows for the possibility that immigrants and natives are imperfect substitutes in production.

## IV. Identification and Estimation

Our data set consists of repeated cross sections of native and immigrant workers with individual information on education, age, and, for immigrants, age at the time of arrival, country of origin, and cohort of entry. Let  $\mathcal{J}$  denote the set of cohorts of entry available in the data,  $\mathcal{E}$  denote the set of considered education groups, and  $\mathcal{T}$  the set census years. The parameters to estimate are the elasticity of substitution between general and specific skills  $\sigma$ , the parameters governing the speed at which immigrants acquire specific skills  $\{\theta_{0k}, \{\theta_{1k\ell}\}_{\ell \in \{1,2,3\}}\}_{k \in \mathcal{K}}$ ,  $\{\theta_{2e}, \{\theta_{3e\ell}\}_{\ell \in \{1,2,3\}}\}_{e \in \mathcal{E}}$ ,  $\{\theta_{4\ell}\}_{\ell \in \{1,2,3\}}$  and  $\{\theta_{5j}, \{\theta_{6j\ell}\}_{\ell=1}^3\}_{j \in \mathcal{J}}$ , and the parameters of the general skill index  $\{\{\eta_{0et}\}_{e \in \mathcal{E}}, \eta_{1t}, \{\eta_{2\ell t}\}_{\ell \in \{1,2,3\}}\}^{t \in \mathcal{T}}$ . This section discusses identification and estimation of these parameters.

### A. Identification

We begin with the identification of the parameters of the general skill shifter  $h_t(E, x)$ . We index by  $i$  individual observations, observed in census year  $t_i$ . Let  $m_i$  denote the labor market in which the individual is observed. In our baseline estimation, labor markets are defined at the state level. Given that our data is cross-sectional, we simplify our notation by using  $m_i$  to denote a market-period pair. Let  $\varepsilon_i$  denote classical measurement error. Observed native (log) wages are given by:

$$\ln w_i = \ln(r_{Gm_i} + r_{Sm_i}) + \eta_{0e(E_i)t_i} + \eta_{1t_i} E_i + \sum_{\ell=1}^3 \eta_{2\ell t_i} x_i^\ell + \varepsilon_i. \quad (10)$$

Considering a separate regression for each census year, normalizing  $\eta_{0et}$  for one educational level, and identifying  $\ln(r_{Gm} + r_{Sm})$  for each market-period  $m$  as the coefficient of the corresponding year-specific state dummy, the general skill index parameters  $\{\{\eta_{0et}\}_{e \in \mathcal{E}}, \eta_{1t}, \{\eta_{2\ell t}\}_{\ell \in \{1,2,3\}}\}^{t \in \mathcal{T}}$  are identified as linear regression coefficients in (10).

Having identified these parameters, the aggregate supply of general skill units in market-period  $m$ ,  $G_m$ , is identified since, conditional on  $E$  and  $x$ , immigrants supply the same amount of general skill units as natives. Moreover, the aggregate supply of specific skill units  $S_t$  only depends on aggregate data, identified parameters, and the parameters of  $s(n, y, k, j, E, x)$ . The left hand side term of Equation (6) is identified as the ratio of observed immigrant wages divided by those predicted for the individual if she was a native, that is the product of the (exponentiated) time dummies  $\ln(r_{Gt} + r_{St})$  and the predicted individual skill shifter  $h_t(E, x)$ . Therefore the parameters of the specific skills production function for immigrants  $s(n, y, k, j, E, x)$  and the elasticity of substitution  $\sigma$  are identified from Equation (6) as the coefficients of a non-linear regression. In particular,



the parameters are identified from the following non-linear regression for immigrants:

$$\begin{aligned} \ln w_i - \ln(\widehat{r_{Gt_i}} + r_{St_i}) - h_{t_i}(\widehat{E_i}, x_i) = & -\ln \left[ 1 + \left( \frac{\widehat{G_{t_i}}}{\widehat{S_{t_i}}} \right)^{\frac{1}{\sigma}} \right] \\ & + \ln \left[ 1 + \left( \frac{\widehat{G_{t_i}}}{\widehat{S_{t_i}}} \right)^{\frac{1}{\sigma}} \left( \begin{aligned} & \theta_{0k} + \sum_{\ell=1}^3 \theta_{1k\ell} y^\ell + \theta_{2e(E)} + \sum_{\ell=1}^3 \theta_{3e(E)\ell} y^\ell \\ & + \sum_{\ell=1}^3 \theta_{4\ell} (x-y)^\ell + \theta_{5j} + \sum_{\ell=1}^3 \theta_{6j\ell} y^\ell \end{aligned} \right) \right] + \varepsilon_i, \end{aligned} \quad (11)$$

where:

$$\widehat{G}_t = \sum_{i=1}^{N_t} \omega_i h_{t_i}(E_i, x_i), \quad (12)$$

and:

$$\widehat{S}_t = \sum_{i=1}^{N_t} \omega_i \left[ n + (1-n) \left( \begin{aligned} & \theta_{0k} + \sum_{\ell=1}^3 \theta_{1k\ell} y^\ell + \theta_{2e(E)} + \sum_{\ell=1}^3 \theta_{3e(E)\ell} y^\ell \\ & + \sum_{\ell=1}^3 \theta_{4\ell} (x-y)^\ell + \theta_{5j} + \sum_{\ell=1}^3 \theta_{6j\ell} y^\ell \end{aligned} \right) \right] h_{t_i}(E_i, x_i), \quad (13)$$

with  $N_t$  denoting the observations in the census sample for period/market  $t$  (including natives and immigrants), and  $\omega_i$  denoting population elevation weights. Therefore,  $s(n, y, k, j, E, x)$  is identified off the wage differences across individuals within a given labor market, and  $\sigma$  is identified off the variation across markets and periods.

### B. Estimation

Our estimation proceeds in two steps. In the first step, we estimate the parameters of the general skill index by running the log-linear wage regression (10) on the observations for native workers. We estimate a separate regression for each census year. In our baseline specification, we define labor markets as state-years, so we include state dummies in each of the regressions to identify skill prices (we estimate the model under different labor market definitions in Section VII). Based on the estimated parameters, in the second step we construct the left hand side term in (11), compute the native population size, which is necessary to compute  $\widehat{G}_t$  and  $\widehat{S}_t$  for each iteration of parameters, and estimate the remaining parameters by NLS on (11) using only the data for immigrant workers.

Regarding inference, the natural reaction to a two-stage estimation procedure would be to correct second-stage standard errors for the econometric error introduced by using first-stage estimates to compute  $\widehat{G}_m$  and  $\widehat{S}_m$  (the only right-hand-side variables that include the outcome of the first-stage estimation). A simple (yet computationally demanding) way of implementing that correction would be to bootstrap the standard errors. However, note that  $\widehat{G}_m$  and  $\widehat{S}_m$  are aggregations of the first-stage-estimated terms. As aggregations, they integrate over the first-stage estimation error, and hence, they are unlikely to introduce any extra error in our second-stage estimation. Therefore, in our estimates below, we provide standard errors computed with the standard NLS formula.

## V. Estimation Results and Goodness of Fit

This section provides an overview of the baseline estimation results, for which labor market competition is determined at the state level. It also provides an evaluation of the goodness of our model in fitting the data. Section VII below, provides results for alternative specifications, alternative definitions of labor markets, and other robustness checks.

### A. Skill index parameters

Table 2 reports the estimates for the general skill index  $h_t(E, x)$ . Each column refers to one census year. The parameter estimates are very much in line with those in the relevant literature (see e.g. Heckman, Lochner and Todd, 2006, for a survey). Beyond the wage effects of different educational degrees (2.1–4.5% for a high school diploma, 7.1–13.9% for some college education, and 21.3–35.7% for a bachelor’s degree for different years), an extra year of education increases wages by 4–6%. In general, returns to education increased over time, in line with the findings in the wage inequality literature. Returns to an extra year of experience also show the standard shape identified in the literature. They are positive but decrease with the level of experience, reaching a value of zero after around 20–25 years of experience (depending on the year) and slightly decreasing thereafter. Recent years also show larger returns to experience, even though they are more concave.

TABLE 2—INDEX OF SKILLS,  $h_t(E, x)$

	Census year:				
	1970	1980	1990	2000	2010
Years of education ( $\eta_{1t}$ )	0.046 (0.001)	0.040 (0.000)	0.045 (0.000)	0.050 (0.001)	0.060 (0.001)
Potential experience ( $\eta_{21t}$ )	0.032 (0.001)	0.043 (0.000)	0.040 (0.000)	0.041 (0.000)	0.050 (0.001)
Pot. exp. squared ( $\eta_{22t} \times 10^2$ )	-0.107 (0.004)	-0.115 (0.002)	-0.078 (0.002)	-0.111 (0.002)	-0.138 (0.004)
Pot. exp. cube ( $\eta_{23t} \times 10^3$ )	0.010 (0.001)	0.008 (0.000)	0.001 (0.000)	0.009 (0.000)	0.010 (0.001)
High school graduate ( $\eta_{02t}$ )	0.021 (0.003)	0.073 (0.002)	0.065 (0.002)	0.062 (0.002)	0.045 (0.004)
Some college ( $\eta_{03t}$ )	0.071 (0.004)	0.090 (0.003)	0.139 (0.003)	0.138 (0.003)	0.130 (0.005)
College graduate ( $\eta_{04t}$ )	0.225 (0.005)	0.213 (0.004)	0.303 (0.004)	0.337 (0.005)	0.357 (0.007)

*Note:* This table presents parameter estimates for the skill index  $h_t(E, x)$ , defined in (4), estimated on native wages year by year. Each column represents a different census year. Labor markets for the computation of skill prices are defined at the state level, that is, state dummies are included in each regression. Sample weights, rescaled by annual hours worked are used in estimation. Robust standard errors in parentheses.

### B. Assimilation parameters

Table 3 reports the parameter estimates that describe the process through which immigrant workers accumulate specific skills,  $s(0, y, k, j, E, x)$ . The first column includes the non-interacted terms (that is  $\theta_{0k}$ ,  $\theta_{2e(E)}$ ,  $\{\theta_{4\ell}\}_{\ell \in \{1,2,3\}}$ , and  $\theta_{5j}$ , along with the constant term, which captures the relative specific skills supplied at arrival by a Mexican high school dropout who arrived in the 1970s cohort with zero years of foreign experience. The constant term is estimated to 0.687, which indicates that the aforementioned immigrant supplies around 69% of the specific skill units supplied by an observationally equivalent native. All other non-interacted terms need to be read as relative shifters at arrival with respect to this base individual. For example, individuals in other education groups are shifted down by around 21–22 percentage points. Immigrants from the other regions of origin are generally more productive at arrival. Yet, with the exception of immigrants from Western countries, all immigrant groups arrive with specific skills that are well below those of comparable native workers.<sup>7</sup> Regarding arrival cohorts, with the exception of the pre-1960s cohorts (for whom the intercept is widely extrapolated), immigrants from earlier cohorts are more similar to natives at arrival, something we discuss in detail below. Finally, results at arrival imply a negative and decreasing return to potential experience abroad in terms of specific skills. The profile is steadily decreasing, reaching a 40 percentage points after 40 years of potential experience, which is the potential experience of an individual arriving around the time of retirement.

The remaining columns of Table 3 show the interaction terms of each of the different characteristics with a polynomial in years since migration,  $\{\theta_{1k\ell}, \theta_{3e(E)\ell}, \theta_{6j\ell}\}_{\ell \in \{1,2,3\}}$ . Given that the magnitudes of these parameters are hard to visualize from the table, we summarize the implied estimates in Figure 4. In particular, the figure plots the implied skill assimilation profiles for different immigrant types. The baseline individual in all figures is a Mexican high school dropout (the most frequent immigrant in the sample) who arrived in the United States in the 1970s (and hence we observe the entire wage profile in the United States) with 10 years of potential experience (the unconditional average in the sample). Figure 4A shows the evolution of specific skills by region of origin, holding the level of education, the year of arrival and the potential experience at arrival constant at their baseline levels. With the exception of immigrants from Western countries, all immigrant groups arrive with specific skills that are well below those of comparable native workers, as we discussed above. Over the 30 years following arrival, all immigrant groups, for this cohort of entry, education level, and experience at entry, then accumulate specific skills such that the gap relative to natives is eventually closed completely.

Figure 4B shows corresponding profiles by level of education, holding the region of

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<sup>7</sup> There are only very few immigrants arriving from Western countries who are high school dropouts. Note that we do not bound the specific-skills share of immigrants at a value of one, allowing their wages to potentially exceed those of comparable natives, which is something that we observe in the data for some immigrant groups.

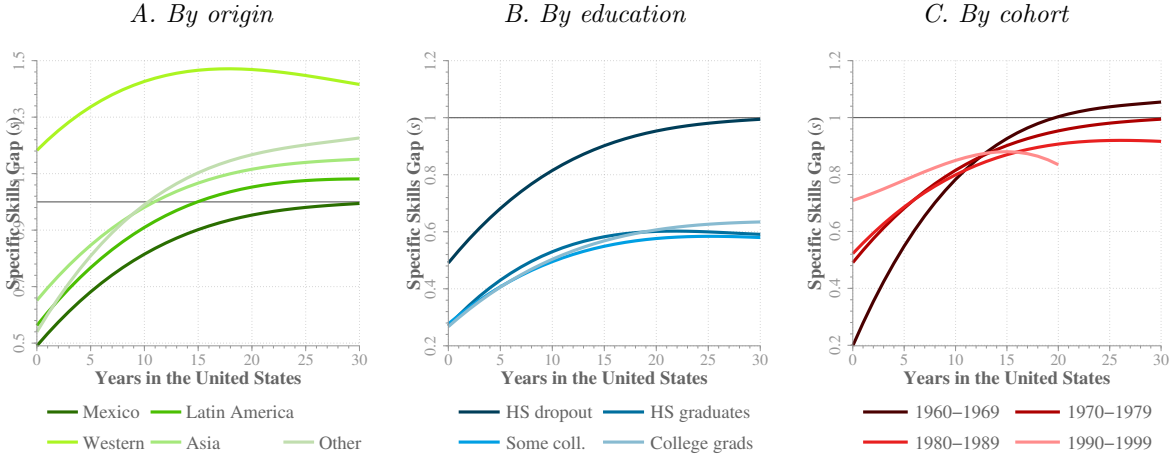
TABLE 3—SPECIFIC SKILLS FOR IMMIGRANTS,  $s(0, y, k, j, E, x)$

	Interactions with years since migration:			
	Intercepts	Linear	Quadratic ( $\times 10^2$ )	Cubic ( $\times 10^3$ )
<b>Region of origin</b> $\theta_{0k}, \{\theta_{1k\ell}\}_{\ell \in \{1,2,3\}}$ :				
Latin America	0.072 (0.010)	0.003 (0.002)	-0.010 (0.017)	0.000 (0.003)
Western countries	0.692 (0.017)	-0.007 (0.004)	-0.017 (0.024)	0.003 (0.004)
Asia	0.161 (0.011)	0.001 (0.003)	-0.008 (0.019)	0.001 (0.004)
Other	0.049 (0.013)	0.019 (0.003)	-0.077 (0.024)	0.011 (0.004)
<b>Education level</b> $\theta_{2e(E)}, \{\theta_{3e(E)\ell}\}_{\ell \in \{1,2,3\}}$ :				
High school graduate	-0.221 (0.010)	-0.006 (0.002)	-0.011 (0.015)	0.003 (0.003)
Some college	-0.213 (0.012)	-0.014 (0.003)	0.039 (0.019)	-0.005 (0.003)
College graduate	-0.223 (0.011)	-0.012 (0.003)	0.042 (0.019)	-0.005 (0.004)
<b>Cohort of arrival</b> $\theta_{5j}, \{\theta_{6j\ell}\}_{\ell \in \{1,2,3\}}$ :				
Pre-1960s	0.398 (0.150)	-0.028 (0.020)	0.206 (0.079)	-0.031 (0.010)
1960s	-0.292 (0.021)	0.083 (0.004)	-0.280 (0.022)	0.033 (0.004)
1970s		0.045 (0.003)	-0.137 (0.017)	0.015 (0.003)
1980s	0.032 (0.011)	0.038 (0.003)	-0.119 (0.019)	0.012 (0.004)
1990s <sup>a</sup>	0.218 (0.011)	0.012 (0.003)	0.072 (0.034)	-0.050 (0.011)
2000s	0.220 (0.012)	0.008 (0.003)		
<b>Experience at entry</b> $\{\theta_{4\ell}\}_{\ell \in \{1,2,3\}}$ :				
Linear term	-0.026 (0.001)			
Quadratic ( $\times 10^2$ )	0.072 (0.006)			
Cubic ( $\times 10^3$ )	-0.008 (0.001)			
<b>Constant</b> (relative specific skills at arrival of a Mexican high school dropout immigrant who arrived in the 1970s cohort with zero years of experience):				
	0.687 (0.011)			

*Note:* This table presents parameter estimates for the specific skill accumulation function for immigrants, defined in (3). Sample weights, rescaled by annual hours worked are used in estimation. The regression is estimated by NLS. Standard errors in parenthesis.

<sup>a</sup> Quadratic and cubic interaction terms for 1990s and 2000s cohorts are grouped in estimation.

FIGURE 4. SKILL ASSIMILATION,  $s(0, y, k, j, E, 10 + y)$



*Note:* The figure displays predicted skill assimilation profiles for different groups based on the baseline estimates reported in Table 3. The baseline individual is a Mexican high school dropout who arrived in the United States in the 1970s with 10 years of potential experience. Panel (A) displays the evolution of specific skills with time spent in the United States by region of origin, Panel (B) by education level and Panel (C) by arrival cohort, holding all other characteristics constant at their baseline levels.

origin, the year of arrival and the potential experience at arrival constant at their baseline levels. Relative to equally educated natives, immigrant high school dropouts arrive with the highest level of specific skills, reflecting the fact that they are more comparable to native dropouts than, for example, immigrant college graduates are to native college graduates. Immigrant high school dropouts also manage to close the skill gap as they spend time in the United States. For the other education groups, only Western immigrants would eventually close the gap (something that is observable combining the results from Figures 4A and 4B). As noted above, the gap at arrival for other educational groups is around 21–22 percentage points wider than high school dropouts. However, after 30 years, these gaps are even larger, widening to roughly 40 percentage points.

Finally, Figure 4C plots the skill assimilation profiles by arrival cohort, omitting the pre-1960s and post-2000s cohorts which we only observe for a short period of time (even though they are accounted for in the estimation, as shown in Table 3). The findings differ somewhat from the standard results in the literature. While the 1960s cohort faced a substantial initial gap of more than 60 percent, this gap actually shrank for subsequent cohorts, to around 50 percent for the 1970s and 1980s cohort and then to only 30 percent for the 1990s cohort. This result could be the consequence of a more selective immigration policy and/or of globalization making U.S.-specific skills (for example, knowledge of English or business culture) more abundant outside of American borders, among other factors. The result, at least in terms of unobservable skills, speaks against the “declining cohort quality” narrative that is widely accepted by the literature. The speed of assimilation of these cohorts also slowed down, the same extent to which the initial gap in specific skills declined across cohorts, not surprisingly because these immigrants have less specific skills to potentially accumulate. All cohorts close or almost close the gap

after 20–30 years, leveling off at gaps that are, in the worst case, at around 90 percent of native counterparts.

### C. Elasticity of substitution

Panel (A) of Table 4 reports our baseline estimate for the elasticity of substitution  $\sigma$ . Our point estimate is 0.039, precisely estimated. Interpreting this magnitude is not straightforward since this elasticity has not been estimated in the literature. In order to facilitate interpretation, we use two different arguments. First, the following identity relating relative skill prices to relative skill supplies provides some economic meaning:

$$\ln \frac{r_{St}}{r_{Gt}} = \frac{1}{\sigma} \ln \frac{G_t}{S_t}. \quad (14)$$

An elasticity of substitution of 0.039 implies  $1/\sigma \approx 25.6$ . Averaging the predicted  $\frac{G_t}{S_t}$  across state labor markets, the relative supplies of general skill units increased from 0.9931 in 1970 to 1.0193 in 2010. In log differences, this change corresponds to an increase of 2.6 log points (2.6%). An inverse elasticity of 25.6 implies that this increase is associated with an increase in the relative prices of specific skills of  $2.6 \times 25.6 \approx 66.6$  log points (roughly 66.6%). This result suggests an important role for labor market competition, which we will further quantify in the next section.

To formally link our parameter  $\sigma$  to the elasticity of substitution between immigrants and natives that has been estimated in the prior literature, let  $m_t \equiv \frac{I_t}{N_t+I_t}$  denote the immigrant share,  $\bar{h} \equiv \frac{G_t}{N_t+I_t}$  the average skill index, and  $\bar{s} \equiv \frac{S_t/\bar{h}-N_t}{I_t}$  the average amount of specific skills of immigrants in the economy. The implied elasticity of substitution between immigrants and natives with the skill set  $\{\bar{h}, \bar{s}\}$ , derived in Appendix B1, is given by:

$$\varepsilon_{NI} = - \frac{\sigma \left[ 1 + [1 + (\bar{s} - 1)m_t]^{\frac{1}{\sigma}} \right] \left[ \bar{s} + [1 + (\bar{s} - 1)m_t]^{\frac{1}{\sigma}} \right]}{(\bar{s} - 1)m_t [1 + (\bar{s} - 1)m_t]^{\frac{1+\sigma}{\sigma}} \left[ 1 - \frac{\bar{s}}{1+(\bar{s}-1)m_t} \right]}. \quad (15)$$

This elasticity tends to infinity (perfect substitutability) when  $\sigma$  approaches infinity or  $\bar{s}$  converges to one. In the long run, when immigrants' specific skill supply converges to that of natives, both groups therefore become perfect substitutes in the labor market.

Based on (15), Panel (B) of Table 4 provides a back-of-the-envelope calculation for the elasticity of substitution between natives and immigrants. Our estimates imply an elasticity of substitution between immigrants and natives of 47.3, at the upper end of the range of estimates presented in Ottaviano and Peri (2012). Having an implied elasticity that is consistent with some of the specifications of Ottaviano and Peri (2012) is quite remarkable, given the very different production function we consider. At the same time, having estimates at the upper range of theirs suggests that our predictions for the competition effect presented below are, if anything, conservative.

A similar expression can be derived for the elasticity of substitution between two distinct



TABLE 4—ELASTICITY OF SUBSTITUTION PARAMETER,  $\sigma$ 

<b>A. Estimated elasticity of substitution between general and specific skills</b>			
	Point estimate	Standard error	Confidence interval
Elasticity of substitution ( $\sigma$ )	0.039	(0.002)	[0.043,0.035]

<b>B. Implied elasticity of substitution between natives and immigrants</b>	
	Elasticity
Natives vs immigrants	47.3

<b>C. Implied elasticity of substitution across different groups</b>				
Years in the United States:	Natives	Years in the United States:		
		30-39 years	20-29 years	10-19 years
0-9 years	47.9	51.3	72.7	124.5
10-19 years	148.4	166.1	332.8	
20-29 years	981.3	1,215.0		
30-39 years	292,821.0			

*Note:* Panel (A) of this table presents estimates for the elasticity of substitution between general and specific skills parameter  $\sigma$ , defined in (1) and obtained by NLS following the procedure described in Section IV.B. Sample weights, rescaled by annual hours worked are used in estimation and in the computation of aggregates. The confidence interval is at 95% of significance level (based on the bands estimated for  $1/\sigma$ ). Panel (B) provides the implied elasticity of substitution between natives and immigrants implied by this estimate, computed according to (15). This elasticity of substitution was computed with  $\bar{s} = 0.804$  and  $m_t = 0.086$ . Panel (C) shows the implied elasticities of substitution across different groups, based on (16). The values of  $s$  at which the expression is evaluated are 0.723, 0.818, 0.894, and 0.978 for the 0–9, 10–19, 20–29, and 30–39 years-in-the-United-States groups respectively, and the values of  $m_{1t}$  are 0.039, 0.032, 0.016, and 0.005 respectively.

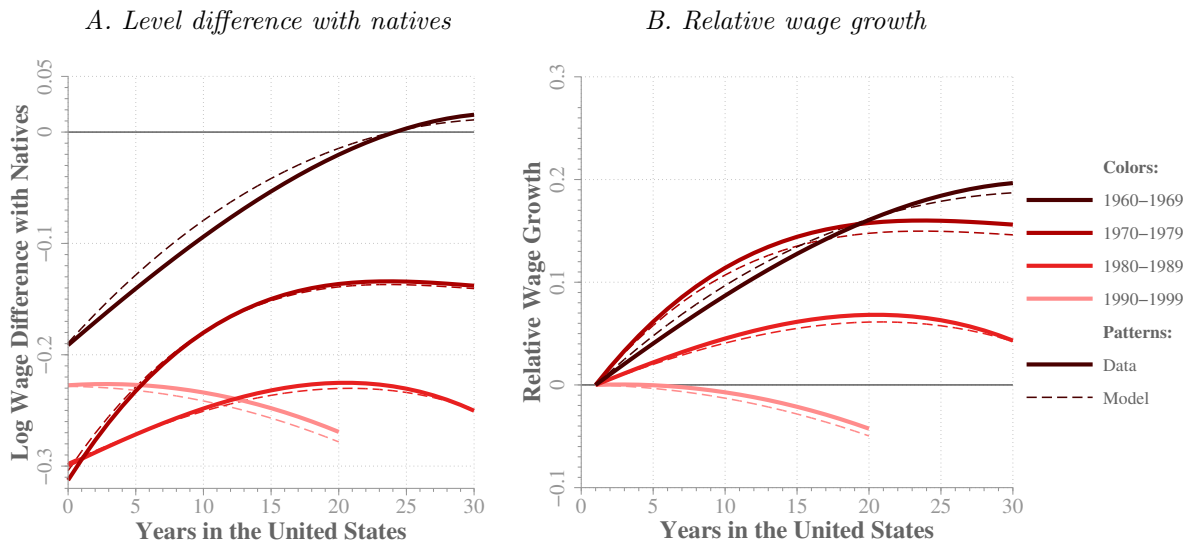
groups of immigrants. This expression, derived in Appendix B2, is:

$$\varepsilon_{12} = - \frac{\sigma \left[ \bar{s}_1 + [1 + (\bar{s} - 1)m_t]^{\frac{1}{\sigma}} \right] \left[ \bar{s}_2 + [1 + (\bar{s} - 1)m_t]^{\frac{1}{\sigma}} \right]}{(\bar{s}_1 - \bar{s}_2)m_{1t} [1 + (\bar{s} - 1)m_t]^{\frac{1+\sigma}{\sigma}} \left[ 1 - \frac{\bar{s}_1}{1+(\bar{s}-1)m_t} \right]}, \quad (16)$$

where  $\bar{s}_1$  and  $\bar{s}_2$  are group-specific but otherwise defined as  $\bar{s}$ , and  $m_{1t} \equiv \frac{I_{1t}}{N_t}$ . This expression tends to infinity when  $\sigma$  approaches infinity or when  $\bar{s}_1$  converges to  $\bar{s}_2$  since, in that case, both immigrant groups are identical in terms of the skills they supply. Equation (16) also provides the elasticity of substitution between natives and a particular group of immigrants as the special case in which  $\bar{s}_1 = 1$  and  $m_{1t} = 1$ . With some algebra, it is easy to show that (15) is the special case of (16) with  $\bar{s}_1 = \bar{s}$ ,  $\bar{s}_2 = 1$ , and  $m_{1t} = m_t$ .

Panel (C) of Table 4 shows how the elasticity of substitution between natives and immigrants evolves as the latter spend time in the U.S. labor market. For example, the elasticity of substitution between natives and recent immigrants arriving within the last 10 years amounts to only 47.9 but increases steadily to 148.9 and 981.3 for immigrants who have been in the country for 10–19 years and 20–29 years, respectively. After 20 years in the country, immigrants and natives are therefore essentially perfect substitutes in the U.S. labor market. Regarding the substitutability between different groups of

FIGURE 5. GOODNESS OF FIT



*Note:* The figure compares the solid lines of Figure 1 (solid) with analogous regression lines estimated on the wages predicted by our model given the estimated parameters (dashed). These regressions include cohort and year dummies, a third order polynomial in age interacted with year dummies, and (an up to) a third order polynomial in years since migration interacted by cohort dummies (in particular, we include the first term of the polynomial for all cohorts, the second term for all cohorts that arrived before year 2000, and the third order term for all cohorts that arrived before 1990).

immigrants, Table 4 also shows that the further apart two arrival cohorts are in time, the less substitutable they are in production. New immigrants therefore primarily compete with their immediate predecessors in the labor market.

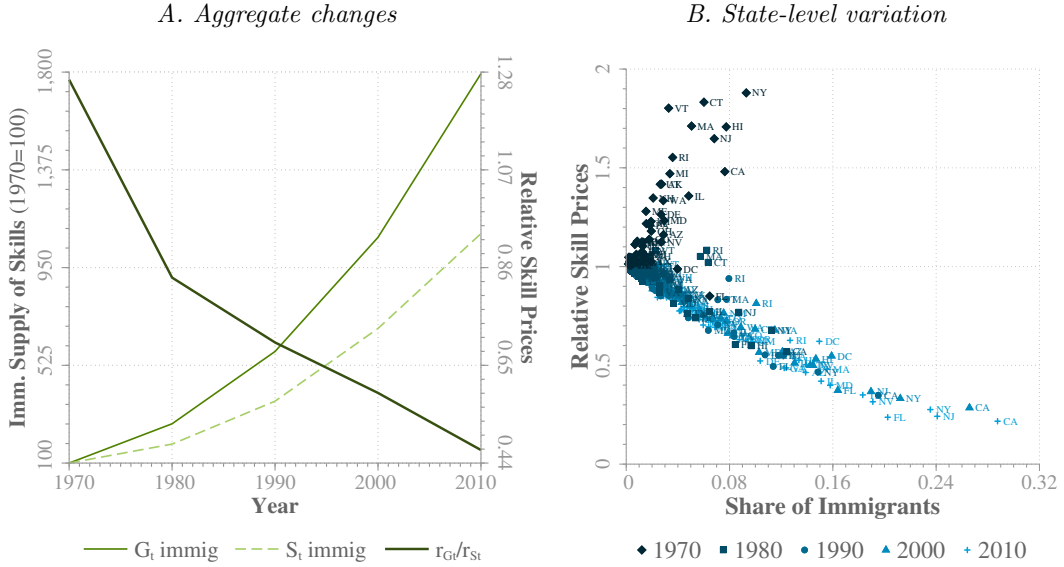
#### D. Goodness of fit

We conclude this section evaluating the goodness of our model in reproducing the wage assimilation profiles documented in Figure 1. This evaluation is done in Figure 5. In the figure, we compare the solid lines of Figure 1 with analogous regression lines estimated on the wages predicted by our model given the estimated parameters. In particular, as in Figure 1, we estimate log wage regressions on cohort and year dummies, a third order polynomial in age interacted with year dummies, and (an up to) a third order polynomial in years since migration interacted by cohort dummies (in particular, we include the first term of the polynomial for all cohorts, the second term for all cohorts that arrived before year 2000, and the third order term for all cohorts that arrived before 1990). We estimate these regressions on real and simulated data. The latter are obtained using our estimated model to predict a wages for every individual in the sample. Results show that all the specifications of the model replicate very well both the wage gap between natives and immigrants, and the decreasing speed of convergence observed in recent decades.

## VI. Labor Market Competition and Immigrant Wage Assimilation

We now use the estimates from our model to evaluate the role of labor market competition in explaining observed wage assimilation patterns. In our analysis, first we illustrate the importance of each of the elements that explain the wage assimilation in the data,

FIGURE 6. CHANGES IN RELATIVE SUPPLIES AND RELATIVE SKILL PRICES



Note: The figure shows the predicted supplies of aggregate skill units of each type by immigrants in each year (left plot, left axis), the relative skill prices implied by these aggregate supplies (left plot, right axis), and the predicted relative skill prices at the state-year level. Aggregate supplies are normalized to 100 in year 1970.

including the competition effects, but also the effects of the changing composition of immigrants based on observable and unobservable characteristics. Then, we provide a wage decomposition that quantifies the relative importance of each mechanism.

#### A. The labor market competition effect

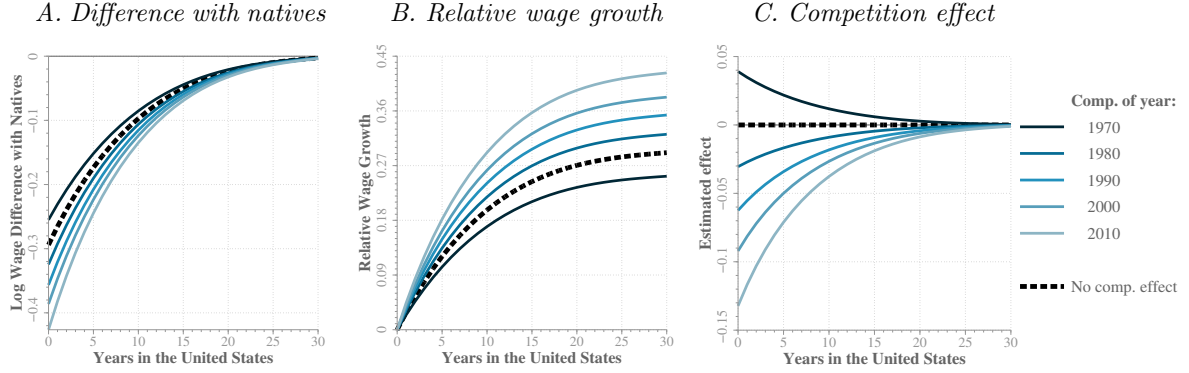
We begin our analysis of the labor market competition effect by quantifying the extent to which competition increased through immigration since 1970. Figure 6A plots the evolution of aggregate general and specific skills supplied by immigrants and the evolution of relative skill prices. Relative to 1970, the supply of general skills by immigrants increased almost eighteenfold by 2010, whereas their supply of specific skills only increased by a factor of eleven. This relative increase in general skills is reflected in a fall of their relative price from 1.26 to 0.46, which decreases the relative wages of immigrants endowed with less specific skills.<sup>8</sup> Figure 6B illustrates the relationship between the population share of immigrants and the relative skill price considering both time and spatial variation, which is the variation exploited to identify  $\sigma$ . In particular, the plot correlates relative skill prices and immigrant shares at the state-year level. The figure shows a clear negative relationship.<sup>9</sup> Relative skill prices are well below 0.3 in states with large immigrant population shares like California, New York or Florida in 2010, while the relative price is around one in many states with close to zero immigrant shares in 1970 and 1980.

<sup>8</sup> The relative prices of skills in 1970s is above one. This is so because we allow specific skill units to go above one to capture that some immigrants earn more than the comparable natives, as already noted in Footnote 7. In 1970, most immigrants were from Western origin and had been in the United States for many years, which explains the result.

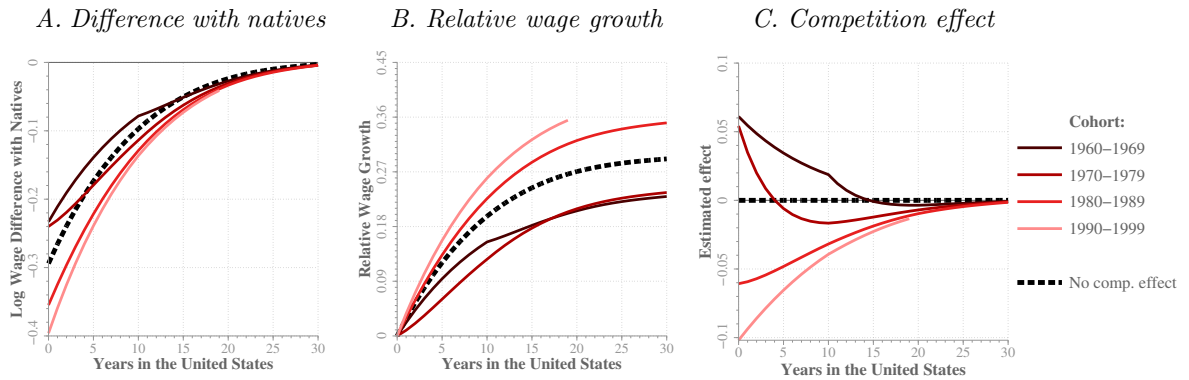
<sup>9</sup> In 1970 several states show a somewhat positive correlation (even though the majority of them concentrate at zero immigrants and relative prices of one). This is again reflecting that highly assimilated Western immigrants (the majority in 1970) often earned higher wages than natives.

FIGURE 7. THE LABOR MARKET COMPETITION EFFECT

I. One-time increase in competition



II. Observed increase in competition for each cohort (dynamic effect)



*Note:* The figure shows wage assimilation profiles of a baseline individual under different counterfactual scenarios. Our baseline individual is a Mexican high school dropout who arrived in the United States in (or with the skills of) the cohort of 1970s with 10 years of potential experience prior to arrival. The thick dashed line assumes relative skill prices are one. Solid lines in Panel (I) are counterfactual scenarios in which the relative skill prices are maintained constant to the level of the indicated years based on the results in 6A. Solid lines in Panel (II) show the predicted assimilation curves for the baseline individual (averaged over states) if he experienced the sequence of relative skill prices experienced by each of the indicated cohorts according to the results in 6B. Plots (A) and (B) in each panel show the wage gap relative to natives and the relative wage growth as in Figure 1. Plots (C) show the difference between the assimilation profiles in each counterfactual scenario and the no-competition benchmark.

According to our model, these changes in the relative supplies and, especially, on relative skill prices should have a substantial impact on the observed patterns of wage assimilation. As we discussed in Section III, the strongest effect of increasing labor market competition is on the initial wage gap at arrival. Furthermore, as we also discussed, it has two types of effects on the relative wage growth. First, since immigrants with lower levels of specific skills are more imperfectly substitutable to natives, they are more affected, and thus the speed of convergence is unambiguously increased through that channel. Second, there is also a dynamic effect generated by the increasing exposure to competition as immigrants spend time in the United States, illustrated with the example in Figure 3.

Figure 7 illustrates the importance of these three effects. The figure plots, under different counterfactual scenarios, the assimilation profile that we would observe for our baseline individual: a Mexican high school dropout who arrived in the United States in (or with the skills of) the cohort of 1970s with 10 years of potential experience prior to

arrival. In all plots, the thick dashed line represents his assimilation profile in the absence of competition effects, that is, if relative prices are equal to one (i.e., either  $\sigma = \infty$  or there are essentially no other immigrants in the market). This profile is the wage counterpart of the estimated skill assimilation patterns shown in Figure 4. In the absence of competition effects, this individual would earn 30% less than the equivalent native, and would assimilate completely after 30 years.

Panels (I) and (II) plot different sets of counterfactuals. Plots (A) and (B) in each panel show the wage gap relative to natives and the relative wage growth as in Figure 1, whereas (C) plots show the difference between the assimilation profiles in each counterfactual scenario and the no-competition benchmark described above. In the top panel, we simulate counterfactual scenarios in which we maintain the level of competition constant to the estimated levels for each of the census years. For example, the darkest line shows the assimilation profile that we would observe for our baseline individual if he faced the relative skill prices of 1970 in his 30 years in the United States. The other lines depict the competition levels of each of the other census years. For each census year, we use the U.S.-wide average relative skill prices depicted in Figure 6A. These counterfactual scenarios thus illustrate the effect of a one-time increase in labor market competition, maintained forever. Therefore, this panel provides evidence on the effects at arrival and on the direct effect on the speed of assimilation, which is predicted to be unambiguously positive.

Figures 7IA through 7IC show an important effect of labor market competition on the initial wage gap at arrival. In particular, the initial wage gap of the baseline individual increases in 17 percentage points (more than a 50% increase relative to the baseline) only by changing the competition levels of 1970 to the ones in 2010. This effect necessarily mitigates as the individual accumulates specific skills and completely vanishes after 30 years, by construction since the individual completely assimilates at that time.

As we discussed above, this (homogeneous) increase in speed of assimilation (compensating the widening of the initial wage gap) is only part of the story. If immigrants are facing increasingly stronger competition as they spend time in the United States, the dynamic effect can slow down wage growth. The counterfactuals represented in Panel (II) incorporate this effect into the analysis. In these counterfactuals, the baseline individual is exposed to the sequence of relative skill prices that each of the cohorts represented in the figure experienced in each state, according to the results presented in Figure 6B. These predicted profiles are then averaged across states weighting each state by the number of immigrants present in the state at the first census in which the cohort is observed. Each cohort is assumed to arrive in the first year of the interval. For the cohort that arrived in the 1960s, we assume that the skill prices they faced during their first 10 years in the United States were those of 1970. For subsequent years and cohorts, the relative skill prices between two census years are linearly interpolated.

The counterfactuals in Panel (II), therefore, add the dynamic competition effect to those

in Panel (I). These plots show the complete competition effect. As evident from the figure, the role of competition effects in explaining assimilation patterns is substantial. In terms of initial wage gap, competition effects explain an increase in the initial wage gap of almost 10 percentage points between the cohorts that arrived in 1960s and in 1990s, naturally in line with the results in Panel (I). As for the speed of assimilation, the dynamic effect seems to play an important role. The cohorts that are more affected are the ones that arrived in the 1960s and 1970s, essentially because the largest drop in relative skill prices of general skills is observed during the 1970s and 1980s. The connection between Panel (I) and Panel (II) graphs is as in Figure 3: throughout a decade, immigrants progressively switch from one blue line to the next.

In sum, Figure 7 shows an important role for labor market competition in explaining the observed patterns of wage assimilation. They alone can explain most of the widening of the initial wage gap. The figure also shows that the increasing sizes of immigrant cohorts slowed down assimilation through the dynamic competition effect, but this effect is not enough to compensate the positive effect through the decreasing degree of substitutability with new immigrant cohorts that older immigrants experience as they spend time in the United States. We revisit and expand these results in Section VI.C below, when we implement our wage decomposition.

### *B. Changing observable characteristics*

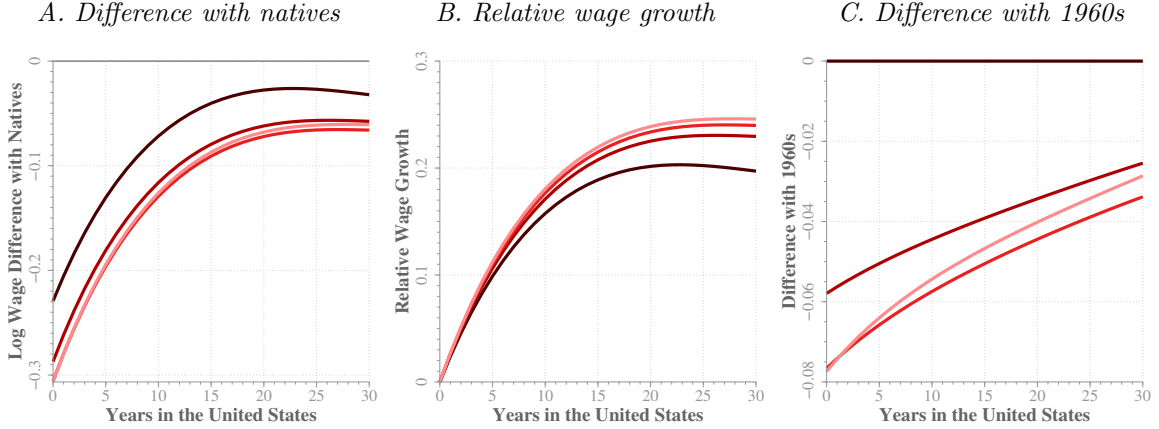
Our framework also allows to disentangle the importance of the changes in country of origin and education composition to explain the observed changes in the assimilation patterns. In order to do so, we simulate two sets of counterfactuals. In each counterfactual, we simulate the assimilation profile for individuals from each region of origin and each educational level, assuming they arrived with the skills of the cohort of 1970s, with 10 years of potential experience abroad, and that they do not face competition effects (i.e., relative skill prices equal one). Then, we average these assimilation profiles using two different distributions of region of origin and education. In the first counterfactual, we keep the distribution of immigrants across education groups constant to 1960 for each region of origin, but adjust the proportion of immigrants from each region of origin as we observe them changing in the data for the different cohorts. In the second counterfactual, we keep the distribution of regions of origin within each education group constant to 1960 levels, but we adjust the distribution of immigrants in each education group across cohorts as we observe them changing in the data.

We plot the results from these two counterfactuals in Figure 8. Panel (I) shows the results for the first counterfactual, and Panel (II) shows the results for the second one. Within each panel, plots (A) and (B) in each panel show the wage gap relative to natives and the relative wage growth as in previous figures, whereas (C) plots show the difference of each cohort with the one that arrived during the 1960s. Results from the top panel

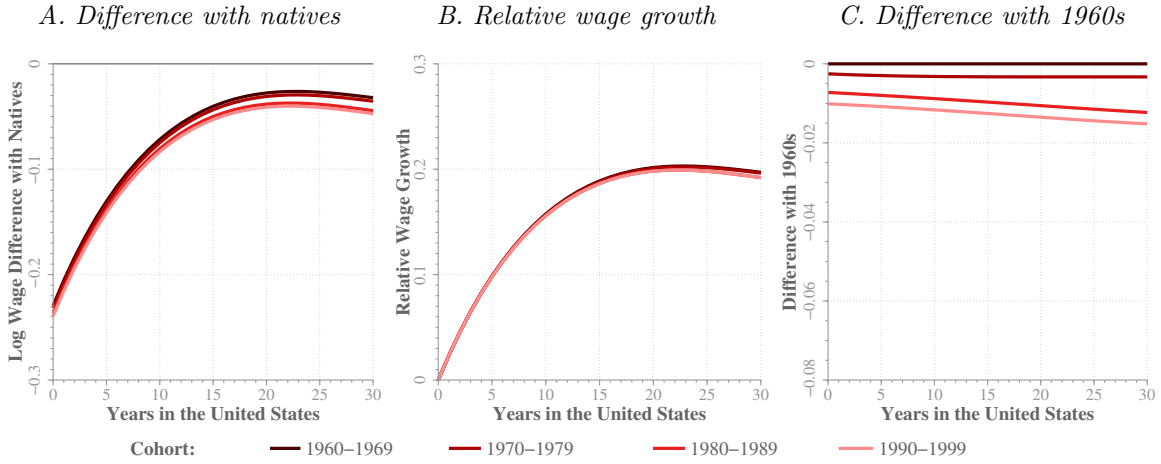


FIGURE 8. COMPOSITION EFFECTS

I. Changing country of origin distribution



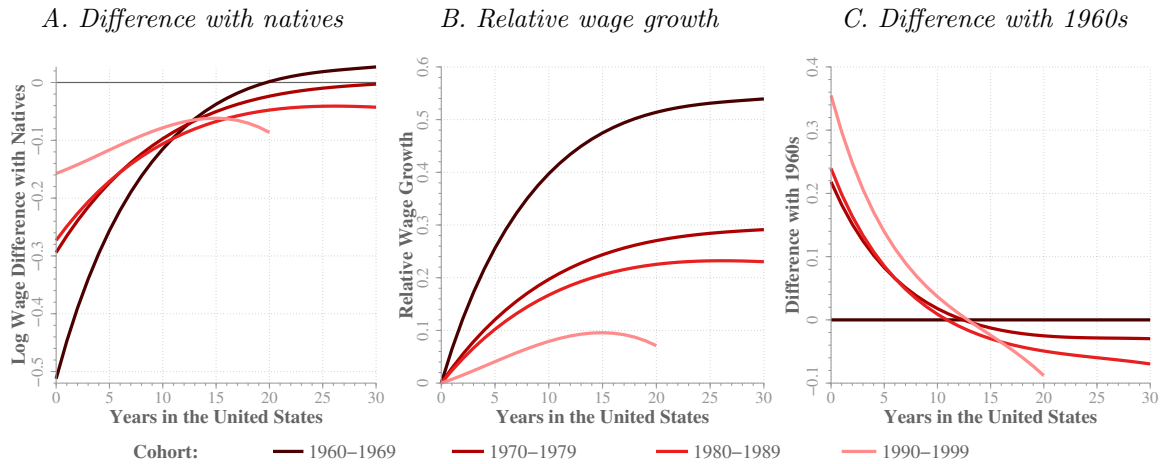
II. Changing education distribution



*Note:* The figure shows wage assimilation profiles for two counterfactual scenarios. In both counterfactuals, we assume no competition effects (relative skill prices equal one). Panel (I) keeps the distribution of immigrants across education groups constant to 1960s for each region of origin, and adjusts the proportion of immigrants from each region of origin as we observe them changing in the data for the different cohorts. Panel (II) keeps the distribution of regions of origin within each education group constant to 1960s, but adjusts the distribution of immigrants in each education group across cohorts as we observe them changing in the data. Plots (A) and (B) in each panel show the wage gap relative to natives and the relative wage growth as in Figure 1. Plots (C) show the difference between each cohort and the cohort of 1960s.

suggest that the change in region of origin composition explain an increase of 6 percentage points of the initial wage gap for the 1970s cohort, and 8 percentage points for the subsequent cohorts. These effects reduce over time, explaining a difference of 3–4 percentage points after 30 years in the United States. Therefore, the increasing importance of Mexico as a region of origin over the years and the decreasing importance of Western countries widened the initial wage gap, but increased the speed of assimilation. The results from Panel (II) show little importance of education in explaining the observed changes in assimilation patterns over the last few decades. In general, changes in education conditional on region of origin explain up to one percentage point of the increase in the observed gaps throughout the assimilation profiles. This limited importance is not very surprising, given that the reference native is a U.S.-born individual with the same level of education.

FIGURE 9. CHANGES IN UNOBSERVABLE SKILLS



*Note:* The figure shows wage assimilation profiles for the baseline individual (a Mexican high school dropout who arrived in the United States with 10 years of experience abroad) changing the unobservable skills to the ones estimated for each of the cohorts. In the counterfactuals, we assume no competition effects (relative skill prices equal one). Plots (A) and (B) show the wage gap relative to natives and the relative wage growth as in Figure 1, whereas (C) shows the difference between each cohort and the cohort of 1960s.

The remaining question is the extent to which unobservable skills of immigrants (or assimilation technology) have changed over different cohorts. Figure 9 plots assimilation profiles for our baseline individual (the Mexican high school dropout who arrived in the United States with 10 years of experience abroad) if he arrived in each of the different cohorts, assuming no competition effects. This figure is, in fact, the wage counterpart of Figure 4C. As evident from the figure, immigrants became more positively selected (contrary to the standard results in the literature) in recent years, even though their speed of assimilation reduced somehow. Between 1960 and 1990, the wage gap at entry for the baseline individual closed from 50% to 16%. However, immigrants fully converged to native wages after 20 years in the 1960s cohort, after 30 years in the 1970s, and finished their convergence at 5–7 percentage points below natives in the 1980s and 1990s. As we mentioned above, this result is consistent with a more selective immigration policy and/or of globalization making U.S.-specific skills (for example, knowledge of English or business culture) more abundant outside of American borders, among other factors.

### C. Wage decomposition

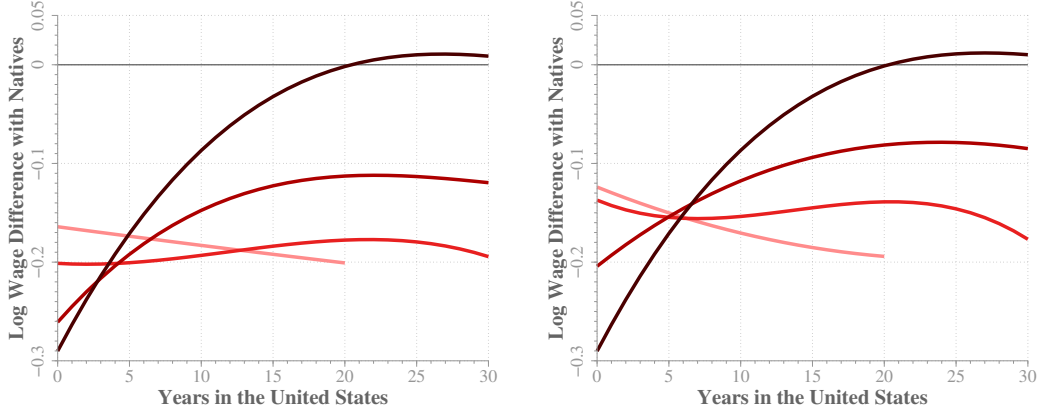
All our discussion so far has concentrated conditional convergence, defining comparable natives based on  $h_t(E, x)$ , and often normalizing immigrants to our baseline individual. In order to close our argument, we now link them to the patterns presented in Figure 1, which do not condition on anything other than age. In particular, we check what part of these raw patterns can be explained by competition effects, and by competition plus composition effects (based on education and region of origin). To do so, we compute two types of counterfactuals and plot them in Figure 10. In the first one (competition effects), we predict wages for every individual in our sample using our model (as in Figure 5) setting relative skill prices equal to one (and holding  $r_{Gt} + r_{St}$ , and, hence, native wages,

FIGURE 10. COMPETITION AND COMPOSITION EFFECTS, AND OBSERVED ASSIMILATION PATTERNS

**I. Level difference with natives**

*A. No competition effects*

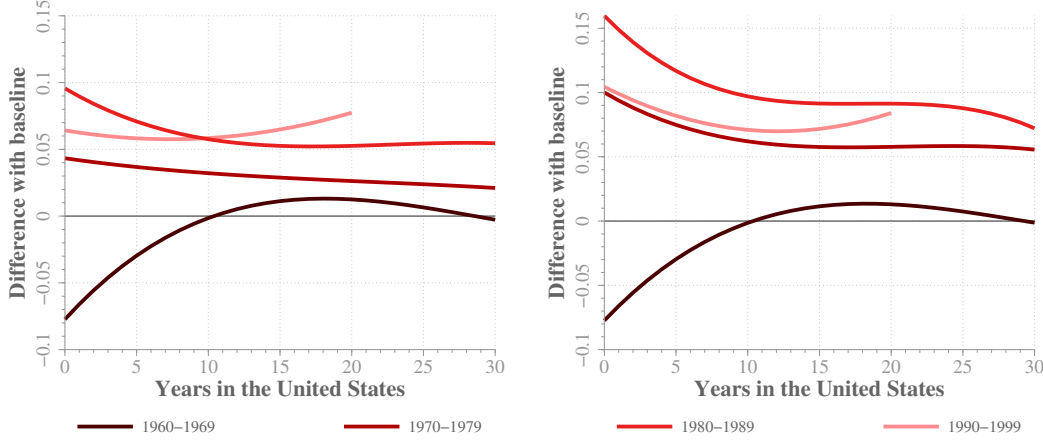
*B. No competition and composition effects*



**II. Difference with the baseline**

*C. No competition effects*

*D. No competition and composition effects*



*Note:* The figure shows the counterfactual predictions of the wage gap between natives and immigrants of different cohorts as they spend time in the United States in the absence of competition effects (left) and in the absence of competition and composition effects (right). Panel (I) shows the wage gap with natives, and Panel (II) shows the difference with respect to the baseline prediction. The assimilation profiles are regression lines analogous to those presented in Figures 1 and 5, fitted on simulated data under the different counterfactuals. Both counterfactuals set relative skill prices to one. The no-composition effects counterfactual adjusts regression sample weights for immigrants to keep the composition in terms of education and region of origin as in the cohort of 1960.

as in the baseline). Using these predictions, we run the same regressions as in Figure 1, and we plot the predicted profiles in Figure 10A. In the second counterfactual, we repeat the same process, but we correct the sampling weights to recalibrate the importance of each origin-education group to keep it constant as in the distribution for the 1960s cohort. This counterfactual adds the composition effect to the effect of labor market competition, as we hold the immigrant characteristics constant to the 1960s cohort. Figure 10B plots the predicted assimilation profiles for this second counterfactual, obtained from the same regressions on the predicted wages using the corrected weights in estimation. Figures 10C and 10D present the difference of each of these lines with respect to the baseline.

The figure shows that 1970s and 1980s cohort would be respectively 3–5 and 5–10 percentage points closer to natives in the absence of labor market competition effects.

Composition effects push them additional 2–5 percentage points further towards natives. Likewise, the cohort of 1990s would be pushed 6 percentage points by the competition effects, and slightly more by composition effects. In all cases, the effects are larger at earlier years, but not dramatically. The cohort of 1960 would be pushed down by the competition effect in the first few years because we estimate relative skill prices to be slightly above one for these years. However, these first 10 years are somewhat extrapolated, so it is difficult to extract very deep conclusions about them.

The result of these effects is that more recent cohorts seem to be closer than natives than older cohorts at arrival, unlike the standard findings in the literature, but the flattening of the convergence profiles remains. This flattening seems to be much stronger than the one predicted in Figure 9. One possible explanation for this apparent discrepancy is the evolution of native wages. While the no-composition-effects counterfactual holds the education distribution of immigrants constant to the 1960s cohort, native education increased substantially over this time period, and so did returns to education, as shown in Table 2. Therefore, the speed of convergence for all cohorts except the 1960s (which already converged at the beginning of the 1980s) might be apparently decreased in these raw assimilation patterns, which do not control for education.

## VII. Robustness checks

In this section, we show that our results are robust to a variety of alternative specifications that account for different concerns that our baseline specification may rise. For each of the alternative specifications, we show the counterfactual assimilation profiles described in Figures 9A, 10A, and, 10B (all other results from these specifications are available upon request from the authors). Our robustness checks focus on possible confounding factors and on different definitions of the labor market.

The first concern that we address is that a larger concentration of immigrants in a given market affects relative skill prices, as in our model, but it can also affect the speed at which immigrants accumulate specific skills. For example, this can occur through better employment networks, lower need for learning English and other specific skills to navigate within the country, or the formation of ghettos among other channels. These channels normally operate through networks of immigrants from the same country of origin. In our first robustness check, thus, we allow the accumulation of skills to depend on the stock of immigrants from the same country of origin working in the same market as the different workers in the sample. This additional variable is allowed to enter linearly, and also interacted with a third order polynomial in years since migration.

Our second robustness check considers an alternative definition of labor market. In particular, we define labor markets as state-education cells, assuming that individuals in different education groups do not compete with each other. Finally, our third robustness check deals with specific-skills-biased demand effects. Our baseline estimation already

TABLE 5—SELECTED PARAMETER ESTIMATES FROM ROBUSTNESS CHECKS

<b>A. Assimilation coefficients associated to the stock of immigrants</b>				
	Intercept	Interaction with years since migration:		
		Linear	Quadratic ( $\times 10^2$ )	Cubic ( $\times 10^3$ )
Stock of immigrants from the same origin country in the state ( $\times 10^6$ )	-0.068 (0.025)	-0.008 (0.006)	0.048 (0.038)	-0.009 (0.007)

<b>B. Demand shifter for relative skill prices</b>		
	Intercept ( $\delta_0$ )	Trend ( $\delta_1$ )
Relative demand shifters	-1.375 (0.169)	0.016 (0.001)

<b>C. Elasticity of substitution between general and specific skills</b>			
	Counterfactual:		
	Networks	State-education definition of labor market	Relative demand shifters
Elasticity of substitution ( $\sigma$ )	0.050 (0.003)	0.060 (0.003)	0.141 (0.032)

*Note:* Panel (A) of this table presents estimates for the parameters associated to the stock of immigrants from the same origin country living in the state of the reference person, introduced in the skill assimilation expression for the first robustness check. Panel (B) shows the intercept and trend parameters for the relative demand shifters estimated in the third robustness check. Panel (C) shows the estimated elasticities of substitution between general and specific skills ( $\sigma$ ) for the different robustness checks. Standard errors in parentheses.

accounts for labor demand shocks allowing  $h_t(E, x)$  to flexibly depend on time. However, these demand effects only account for general shifts in the demand for skills (for example, skill-biased technical change increasing the demand for college workers). The demand effects could additionally be biased towards (or against) specific skills, thus affecting also the relative skill prices. In order to account for this type of biased demand effects, our third robustness check considers the following modification of our production function:

$$Y_t = A_t \left( G_t^{\frac{\sigma-1}{\sigma}} + \delta_t S_t^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \quad (17)$$

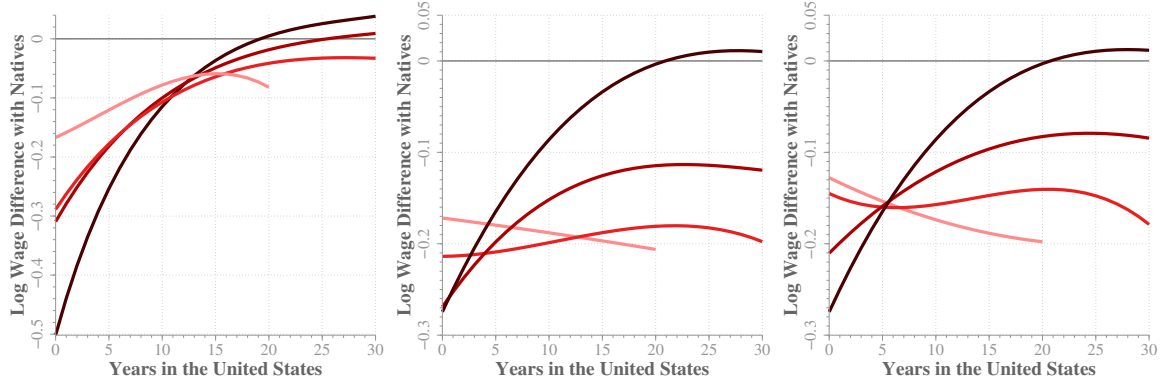
where, similar to other papers in the wage inequality literature,  $\delta_t = \exp(\delta_0 + \delta_1 t)$ . This change implies that  $r_{S_t}/r_{G_t}$  is now  $\delta_t (G_t/S_t)^{\frac{1}{\sigma}}$ . Assuming that these technology parameters are common across states, its identification follows trivially from state-level variation in the relative supplies of skills and from the long run trend in relative wages. In this case, our counterfactuals with no competition effects set  $\sigma = \infty$ , but keep the trend in relative skill prices implied by  $\delta_t$ .

Table 5 summarizes some of the parameter estimates obtained across different counterfactuals. Panel (A) shows that a larger stock of immigrants from the same country of origin living in the same state as the respondent have a negative (though relatively small)

FIGURE 11. COUNTERFACTUAL SIMULATIONS FOR ROBUSTNESS CHECKS

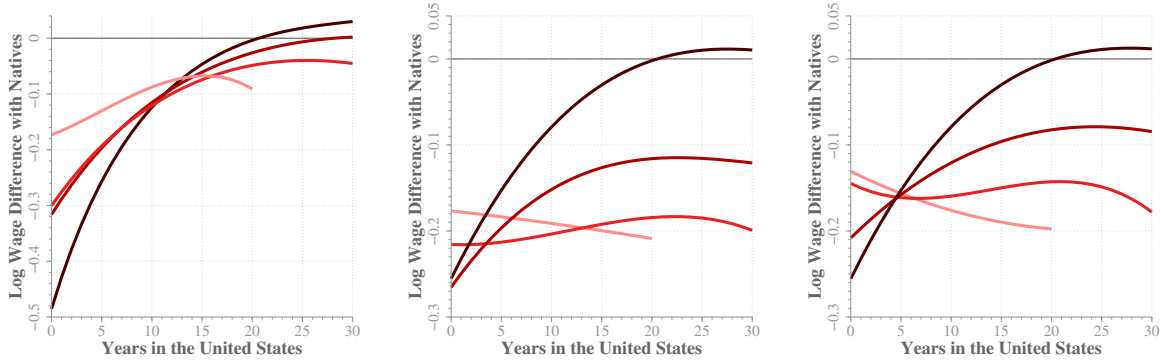
**I. Networks in assimilation**

*A. Changes in unobservable skills    B. No competition effects    C. No competition and composition*



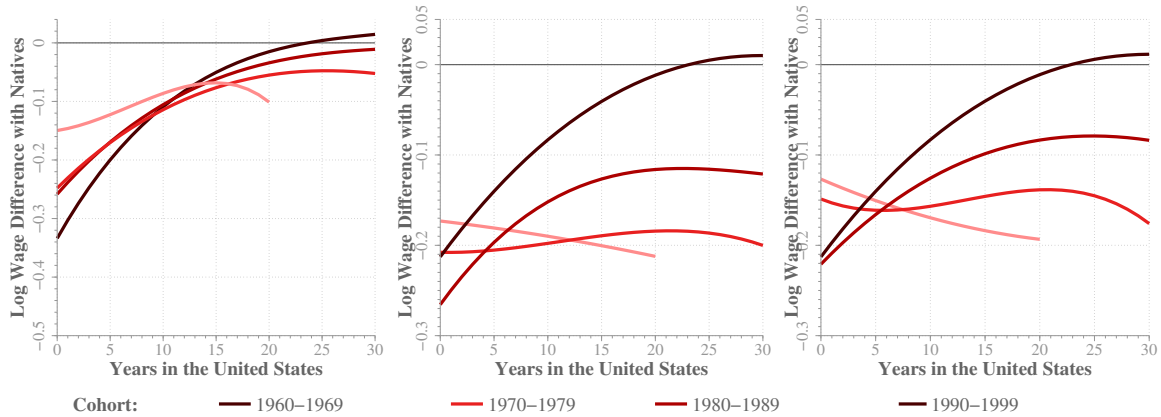
**II. State-education definition of labor markets**

*A. Changes in unobservable skills    B. No competition effects    C. No competition and composition*



**III. Relative demand shifters**

*A. Changes in unobservable skills    B. No competition effects    C. No competition and composition*



*Note:* The figure reproduces the counterfactual assimilation profiles described in Figures 9A, 10A, and, 10B for the three robustness checks described in the text: controlling for networks in the assimilation profiles, Panel (I); defining labor markets as state-education cells, Panel (II); and controlling for relative demand shifters, Panel (III). In Figure 11IA, the baseline individual is evaluated at a network of 0.32 million (the average in the sample for Mexican high school dropout workers that arrived in the cohort of 1970). In Panel (III), individuals are assumed to arrive in the first year of the interval the cohort refers to.

impact on the initial wage gap. The initial wage gap is reduced by almost 7 percentage points for every million of immigrants. The unconditional average is relatively small, 0.11 millions, and the values range from zero to 0.76 millions. This implies that on average,



initial wage gap is increased by 0.8 percentage points, going up to 5.2 percentage points in the worst case in the sample. The estimated effects on the wage growth are small and statistically insignificant. In particular, point estimates imply that one additional million of immigrants in the network variable reduce the 30-year wage increase in only 5 percentage points. Panel (B) shows the relative demand shifters. Point estimates suggest that the relative demand for specific skills increased substantially, roughly at a rate of roughly 1.6 percent every year. That increase suggests that skill-biased technical change increased the relative demand of specific skills in recent years, which is consistent with the economy moving from manufacturing towards services. Panel (C) shows the elasticities of substitution between general and specific skills estimated for each of the three specifications. Even though point estimates are statistically different from the baseline estimates, they are in the same ballpark, at least judging by the similar counterfactual predictions they generate, as we shown below.

Figure 11 shows the counterfactual assimilation profiles described in Figures 9A, 10A, and, 10B computed with the estimates obtained in the three robustness checks. As evident from the picture, the three sets of estimates generate very similar predictions with the exception of the first 10 years in the United States for the cohort of 1960 in the relative demand shifters specification. As we argued above, however, these years are mostly extrapolated, and, indeed, the remaining years for this cohort are also very similar to the baseline results. Therefore, Figure 11 shows that our results are robust to the different concerns raised above.

## VIII. Conclusions

### REFERENCES

- Abramitzky, Ran, Leah Platt Boustan, and Katherine Eriksson**, “A Nation of Immigrants: Assimilation and Economic Outcomes in the Age of Mass Migration,” *Journal of Political Economy*, June 2014, 122 (3), 467–506.
- Albert, Christoph**, “The Labor Market Impact of Immigration: Job Creation vs. Job Competition,” mimeo, CEMFI, January 2019.
- Altonji, Joseph G. and David E. Card**, “The Effects of Immigration on the Labor Market Outcomes of Less-skilled Natives,” in John M. Abowd and Richard B. Freeman, eds., *Immigration, Trade and the Labor Market*, Chicago: The University of Chicago Press, 1991, chapter 7, pp. 201–234.
- Antecol, Heather, Peter Kuhn, and Stephen J. Trejo**, “Assimilation via Prices or Quantities? Sources of Immigrant Earnings Growth in Australia, Canada, and the United States,” *Journal of Human Resources*, Fall 2006, 41 (4), 821–840.
- Baker, Michael and Dwayne Benjamin**, “The Performance of Immigrants in the Canadian Labor Market,” *Journal of Labor Economics*, July 1994, 12 (3), 369–405.

- Battisti, Michele, Gabriel Felbermayr, Giovanni Peri, and Panu Poutvaara**, “Immigration, Search, and Redistribution: A Quantitative Assessment of Native Welfare,” *Journal of the European Economic Association*, August 2018, 16 (4), 1137–1188.
- Beaman, Lori A.**, “Social Networks and the Dynamics of Labour Market Outcomes: Evidence from Refugees Resettled in the U.S.,” *Review of Economic Studies*, January 2012, 79 (1), 128–161.
- Bell, Brian D.**, “The Performance of Immigrants in the United Kingdom: Evidence from the GHS,” *Economic Journal*, March 1997, 107 (441), 333–344.
- Borjas, George J.**, “Assimilation, Changes in Cohort Quality, and the Earnings of Immigrants,” *Journal of Labor Economics*, October 1985, 3 (4), 463–489.
- , “Self-Selection and the Earnings of Immigrants,” *American Economic Review*, September 1987, 77 (4), 531–553.
- , “National Origin and the Skills of Immigrants in the Postwar Period,” in George J. Borjas and Richard B. Freeman, eds., *Immigration and the Workforce: Economic Consequences for the United States and Source Areas*, Chicago: The University of Chicago Press, 1992, chapter 1, pp. 17–47.
- , “Assimilation and Changes in Cohort Quality Revisited: What Happened to Immigrant Earnings in the 1980s?,” *Journal of Labor Economics*, April 1995, 13 (2), 201–245.
- , “The Economic Analysis of Immigration,” in Orley C. Ashenfelter and David E. Card, eds., *Handbook of Labor Economics*, Vol. 3A, Amsterdam: North-Holland Publishing Company, 1999, chapter 28, pp. 1697–1760.
- , “The Labor Demand Curve Is Downward Sloping: Reexamining the Impact of Immigration on the Labor Market,” *Quarterly Journal of Economics*, November 2003, 118 (4), 1335–1374.
- , *Immigration Economics*, Cambridge: Harvard University Press, 2014.
- , “The Slowdown in the Economic Assimilation of Immigrants: Aging and Cohort Effects Revisited Again,” *Journal of Human Capital*, Winter 2015, 9 (4), 483–517.
- **and Rachel M. Friedberg**, “Recent Trends in the Earnings of New Immigrants to the United States,” NBER Working Paper No. 15406, October 2009.
- Bratsberg, Bernt and James F. Ragan Jr.**, “The Impact of Host-Country Schooling on Earnings: A Study of Male Immigrants in the United States,” *Journal of Human Resources*, Winter 2002, 37 (1), 63–105.
- Cadena, Brian C., Brian Duncan, and Stephen J. Trejo**, “The Labor Market Integration and Impacts of US Immigrants,” in Paul W. Miller Barry R. Chiswick, ed., *Handbook of the Economics of International Migration*, Vol. 1B, Amsterdam: North-Holland Publishing Company, 2015, chapter 22, pp. 1197–1259.
- Card, David E.**, “The Impact of the Mariel Boatlift on the Miami Labor Market,” *Industrial and Labor Relations Review*, January 1990, 43 (2), 245–257.

- , “Is the New Immigration Really So Bad?,” *Economic Journal*, November 2005, *115* (507), F300–F323.
- **and Thomas Lemieux**, “Can Falling Supply Explain The Rising Return To College For Younger Men? A Cohort-Based Analysis,” *Quarterly Journal of Economics*, May 2001, *116* (2), 705–745.
- Chassamboulli, Andri and Giovanni Peri**, “The Labor Market Effects of Reducing the Number of Illegal Immigrants,” *Review of Economic Dynamics*, October 2015, *18* (4), 792–821.
- Chiswick, Barry R.**, “The Effect of Americanization on the Earnings of Foreign-born Men,” *Journal of Political Economy*, October 1978, *86* (5), 897–921.
- Duleep, Harriet Orcutt and Daniel J. Dowhan**, “Insights from Longitudinal Data on the Earnings Growth of U.S. Foreign-Born Men,” *Demography*, August 2002, *39* (3), 485–506.
- Dustmann, Christian**, “Earnings Adjustment of Temporary Migrants,” *Journal of Population Economics*, May 1993, *6* (2), 153–168.
- , **Tommaso Frattini, and Ian Preston**, “The Effect of Immigration along the Distribution of Wages,” *Review of Economic Studies*, January 2013, *80* (1), 145–173.
- , **Uta Schönberg, and Jan Stuhler**, “The Impact of Immigration: Why Do Studies Reach Such Different Results?,” *Journal of Economic Perspectives*, Fall 2016, *30* (4), 31–56.
- , – , **and** – , “The Impact of Immigration on Local Labor Markets: Evidence from the Opening of the Czech-German Border,” *Quarterly Journal of Economics*, February 2017, *132* (1), 435–483.
- Eckstein, Zvi and Yoram Weiss**, “On the Wage Growth of Immigrants: Israel 1990–2000,” *Journal of the European Economic Association*, June 2004, *2* (4), 665–695.
- Edin, Per-Anders, Robert J. LaLonde, and Olof Åslund**, “Emigration of Immigrants and Measures of Immigrant Assimilation: Evidence from Sweden,” *Swedish Economic Policy Review*, 2000, *7*, 163–204.
- Friedberg, Rachel M.**, “You Can’t Take It with You? Immigrant Assimilation and the Portability of Human Capital,” *Journal of Labor Economics*, April 2000, *18* (2), 221–251.
- **and Jennifer Hunt**, “The Impact of Immigrants on Host Country Wages, Employment and Growth,” *Journal of Economic Perspectives*, Spring 1995, *9* (2), 23–44.
- Glitz, Albrecht**, “The Labor Market Impact of Immigration: A Quasi-Experiment Exploiting Immigrant Location Rules in Germany,” *Journal of Labor Economics*, January 2012, *30* (1), 175–213.
- Hatton, Timothy J. and Andrew Leigh**, “Immigrants Assimilate as Communities, Not Just as Individuals,” *Journal of Population Economics*, April 2011, *24* (2), 389–419.

- Heckman, James J., Lance Lochner, and Petra E. Todd**, “Earnings Functions, Rates of Return, and Treatment Effects: The Mincer Equation and Beyond,” in Eric A. Hanushek and Finis Welch, eds., *Handbook of the Economics of Education*, Vol. 1, Amsterdam: Elsevier Science, 2006, chapter 7, pp. 307–458.
- Hu, Wei-Yin**, “Immigrant Earnings Assimilation: Estimates from Longitudinal Data,” *American Economic Review: Papers and Proceedings*, May 2000, *90* (2), 368–372.
- Jasso, Guillermina, Mark R. Rosenzweig, and James P. Smith**, “The Changing Skill of New Immigrants to the United States: Recent Trends and Their Determinants,” in George J. Borjas, ed., *Issues in the Economics of Immigration*, Chicago: The University of Chicago Press, 2000, chapter 5, pp. 185–226.
- Jeong, Hyeok, Yong Kim, and Iourii Manovskii**, “The Price of Experience,” *American Economic Review*, February 2015, *105* (2), 784–815.
- Katz, Lawrence F. and Kevin M. Murphy**, “Changes in Relative Wages, 1963–1987: Supply and Demand Factors,” *Quarterly Journal of Economics*, February 1992, *107* (1), 35–78.
- Kerr, Sari Pekkala and William R. Kerr**, “Economic Impacts of Immigration: A Survey,” *Finnish Economic Papers*, Spring 2011, *24* (1), 1–32.
- Kossoudji, Sherrie A.**, “Immigrant Worker Assimilation: Is It a Labor Market Phenomenon?,” *Journal of Human Resources*, Summer 1989, *24* (3), 1989.
- Krusell, Per, Lee E. Ohanian, José-Víctor Ríos-Rull, and Giovanni L. Violante**, “Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis,” *Econometrica*, September 2000, *68* (5), 1029–1054.
- LaLonde, Robert J. and Robert H. Topel**, “The Assimilation of Immigrants in the U.S. Labor Market,” in George J. Borjas and Richard B. Freeman, eds., *Immigration and the Workforce: Economic Consequences for the United States and Source Areas*, Chicago: The University of Chicago Press, 1992, chapter 3, pp. 67–92.
- Llull, Joan**, “Immigration, Wages, and Education: A Labor Market Equilibrium Structural Model,” *Review of Economic Studies*, July 2018, *85* (3), 1852–1896.
- , “The Effect of Immigration on Wages: Exploiting Exogenous Variation at the National Level,” *Journal of Human Resources*, Summer 2018, *53* (3), 608–622.
- Lubotsky, Darren**, “Chutes or Ladders? A Longitudinal Analysis of Immigrant Earnings,” *Journal of Political Economy*, October 2007, *115* (5), 820–867.
- , “The Effect of Changes in the U.S. Wage Structure on Recent Immigrant’s Earnings,” *Review of Economics and Statistics*, February 2011, *93* (1), 59–71.
- Manacorda, Marco, Alan Manning, and Jonathan Wadsworth**, “The Impact of Immigration on the Structure of Wages: Theory and Evidence from Britain,” *Journal of the European Economic Association*, February 2012, *10* (1), 120–151.
- Monràs, Joan**, “Immigration and Wage Dynamics: Evidence from the Mexican Peso

Crisis,” IZA Discussion Paper n. 8924, November 2015.

**Ottaviano, Gianmarco I. P. and Giovanni Peri**, “Rethinking the Effect of Immigration on Wages,” *Journal of the European Economic Association*, February 2012, 10 (1), 152–197.

**Peri, Giovanni and Chad Sparber**, “Task Specialization, Immigration, and Wages,” *American Economic Journal: Applied Economics*, July 2009, 1 (3), 135–169.

**Piyapromdee, Suphanit**, “The Impact of Immigration on Wages, Internal Migration, and Welfare,” mimeo, University College London, January 2019.

**Ruggles, Steven, Sarah Flood, Ronald Goeken, Josiah Grover, Erin Meyer, Jose Pacas, and Matthew Sobek**, “IPUMS USA: Version 8.0 [dataset],” Minneapolis, MN: Minnesota Population Center, 2018.

**Schoeni, Robert F.**, “New Evidence on the Economic Progress of Foreign-Born Men in 1970s and 1980s,” *Journal of Human Resources*, Autumn 1997, 32 (4), 683–740.

**Smith, James P.**, “Immigrants and the Labor Market,” *Journal of Labor Economics*, April 2006, 24 (2), 203–233.

#### APPENDIX A: VARIABLE DEFINITIONS

**Immigrants** They are defined as foreign-born individuals with non-American parents.

**Wages** Hourly wages are computed combining information on annual wage and salary income, the number of weeks worked during the year, and the usual number of hours worked per week. In 1970, weeks worked is only available in intervals, so we impute the average number of weeks worked for individuals in each of the intervals in the remaining years. We deflate wages to US dollars of 1999 using the Consumer Price Index for All Urban Consumers (CPI-U) from the Bureau of Labor Statistics. Extreme observations with an hourly wage lower than 1 US\$ or larger than 250 US\$ are dropped.

**Education** Years of education is obtained mapping the detailed classification of education from each census into years. Educational level categorizes individuals in four education groups: high school dropouts (<12 years of education), high school graduates (12), persons with some college (13-15), and college graduates (16+).

**Immigrant cohorts** Based on the available information of year of immigration for the different censuses, we group immigrant cohorts into six groups as: pre-1960, 1960–69, 1970–79, 1980–1989, 1990–1999, and 2000–09.

**Years since migration** Years in the United States are constructed subtracting the raw year of immigration available in the census to the census date. When this variable is reported in intervals, we use the last year of the interval.

**Region of birth** We consider five regions of birth for immigrants: Mexico; Other Latin America (Caribbean, Central America, and South America); Western Countries (Western

Europe, Israel, Australia, New Zealand, and Canada); South East Asia (China, Hong Kong, Macau, Taiwan, Singapore, Korea, Japan, and the Philippines); and the rest of the world.

## APPENDIX B: DERIVATION OF THE ELASTICITIES OF SUBSTITUTION

### B1. Elasticity of Substitution between Natives and Immigrants, (15)

Let  $I_t$  and  $N_t$  denote the stock of immigrants and natives in the economy and define the share of immigrants as  $m_t \equiv \frac{I_t}{N_t + I_t}$ . The relative supply of general versus specific skills is then given by  $\frac{G_t}{S_t} = \frac{1 + I_t/N_t}{1 + \bar{s}I_t/N_t}$  where  $\bar{s} \equiv \frac{S_t/\bar{h} - N_t}{I_t}$  denotes the average specific skills of immigrants and  $\bar{h} \equiv \frac{G_t}{N_t + I_t}$  the average skill index in the economy. The elasticity of substitution between natives and immigrants is defined as  $\varepsilon_{NI} \equiv d \ln(N_t/I_t)/d \ln MRTS_{IN}$ , where  $MRTS_{IN}$  is the marginal rate of technical substitution between immigrants and natives. In equilibrium, the  $MRTS_{IN}$  is equal to the relative wages between immigrants and natives, given by (6). Evaluated at  $\bar{s}$  and  $\bar{h}$ , log-differentiating  $MRTS_{IN}$  yields:

$$d \ln MRTS_{IN} = \frac{\bar{s} \frac{1}{\sigma} \left(\frac{G_t}{S_t}\right)^{\frac{1-\sigma}{\sigma}} d \ln \left(\frac{G_t}{S_t}\right)}{1 + \bar{s} \left(\frac{G_t}{S_t}\right)^{\frac{1}{\sigma}}} - \frac{\frac{1}{\sigma} \left(\frac{G_t}{S_t}\right)^{\frac{1-\sigma}{\sigma}} d \ln \left(\frac{G_t}{S_t}\right)}{1 + \left(\frac{G_t}{S_t}\right)^{\frac{1}{\sigma}}} = \frac{(\bar{s} - 1) \left(\frac{G_t}{S_t}\right)^{\frac{1-\sigma}{\sigma}} d \ln \left(\frac{G_t}{S_t}\right)}{\sigma \left[1 + \left(\frac{G_t}{S_t}\right)^{\frac{1}{\sigma}}\right] \left[1 + \bar{s} \left(\frac{G_t}{S_t}\right)^{\frac{1}{\sigma}}\right]}. \quad (B1)$$

To derive an expression for  $d \ln(N_t/I_t)$ , first note that:

$$d \ln \left(\frac{G_t}{S_t}\right) = d \ln \left(\frac{1 + \frac{I_t}{N_t}}{1 + \bar{s} \frac{I_t}{N_t}}\right) = \frac{d \frac{I_t}{N_t}}{1 + \frac{I_t}{N_t}} - \frac{\bar{s} d \frac{I_t}{N_t}}{1 + \bar{s} \frac{I_t}{N_t}} = - \left(\frac{I_t}{N_t + I_t} - \frac{\bar{s} I_t}{N_t + \bar{s} I_t}\right) d \ln \left(\frac{N_t}{I_t}\right), \quad (B2)$$

where the last result uses  $d \ln \left(\frac{N_t}{I_t}\right) = -d \frac{I_t}{N_t} / \frac{I_t}{N_t}$ . Substituting (B2) into the expression for  $\varepsilon_{NI}$ , re-writing all instances of  $G_t/S_t$  in terms of  $m_t$  and  $\bar{s}$ , and rearranging gives (15). ■

### B2. Elasticity of Substitution across Immigrant Groups, (16)

Let  $I_{it}$  for  $i = 1, 2, 3$  denote the stock of immigrants in groups 1 and 2, for which the elasticity of substitution is to be estimated, and 3, which includes all remaining immigrants. Define  $\bar{s}_1$ ,  $\bar{s}_2$ , and  $\bar{s}_3$  implicitly as  $S_t = \bar{h}(N_t + \bar{s}_1 I_{1t} + \bar{s}_2 I_{2t} + \bar{s}_3 I_{3t})$ . Evaluating the marginal rate of technical substitution at  $\bar{s}_1$ ,  $\bar{s}_2$  and  $\bar{h}$ , and log-differentiating it with respect to the change in the supplies of these two groups gives:

$$d \ln MRTS_{21} = \frac{\bar{s}_2 \frac{1}{\sigma} \left(\frac{G_t}{S_t}\right)^{\frac{1-\sigma}{\sigma}} d \ln \left(\frac{G_t}{S_t}\right)}{1 + \bar{s}_2 \left(\frac{G_t}{S_t}\right)^{\frac{1}{\sigma}}} - \frac{\bar{s}_1 \frac{1}{\sigma} \left(\frac{G_t}{S_t}\right)^{\frac{1-\sigma}{\sigma}} d \ln \left(\frac{G_t}{S_t}\right)}{1 + \bar{s}_1 \left(\frac{G_t}{S_t}\right)^{\frac{1}{\sigma}}} = \frac{(\bar{s}_2 - \bar{s}_1) \left(\frac{G_t}{S_t}\right)^{\frac{1-\sigma}{\sigma}} d \ln \left(\frac{G_t}{S_t}\right)}{\sigma \left[1 + \bar{s}_1 \left(\frac{G_t}{S_t}\right)^{\frac{1}{\sigma}}\right] \left[1 + \bar{s}_2 \left(\frac{G_t}{S_t}\right)^{\frac{1}{\sigma}}\right]}.$$

In this case, the elasticity of substitution is defined as  $\varepsilon_{12} \equiv d \ln(I_{1t}/I_{2t})/d \ln MRTS_{21}$ , which we evaluate holding constant the total population. Define  $m_{it} \equiv \frac{I_{it}}{N_t}$ . The change



in the relative supplies of skills  $d \ln (G_t/S_t)$  is given by:

$$\begin{aligned} d \ln \left( \frac{G_t}{S_t} \right) &= d \ln \frac{N_t + I_{1t} + I_{2t} + I_{3t}}{N_t + \bar{s}_1 I_{1t} + \bar{s}_2 I_{2t} + \bar{s}_3 I_{3t}} = \frac{dI_{1t} + dI_{2t}}{N_t + I_t} - \frac{\bar{s}_1 dI_{1t} + \bar{s}_2 dI_{2t}}{N_t + \bar{s} I_t} \\ &= - \left[ m_{1t} - \frac{\bar{s}_1 m_{1t}}{1 + \bar{s} m_t} \right] d \ln \left( \frac{I_{1t}}{I_{2t}} \right) + \left( m_{1t} + m_{2t} - \frac{\bar{s}_1 m_{1t} + \bar{s}_2 m_{2t}}{1 + (\bar{s} - 1) m_t} \right) d \ln I_{2t}. \end{aligned}$$

Focusing on the case in which  $\ln \left( \frac{I_{1t}}{I_{2t}} \right)$  changes because of a change in  $I_{1t}$  alone (i.e., the case in which  $d \ln I_{2t} = 0$ ), inserting this identity into the expression for  $\varepsilon_{12}$  and re-writing all instances of  $(G_t/S_t)$  in terms of  $m_t$ ,  $\bar{s}$ ,  $m_{1t}$  and  $\bar{s}_1$  yields (16) upon rearrangement. ■

### APPENDIX C: ADDITIONAL TABLES AND FIGURES

TABLE C1—ADDITIONAL DESCRIPTIVES (NATIVES AND IMMIGRANTS)

	Census year:				
	1970	1980	1990	2000	2010
Immigrant share (%)	3.6	4.9	7.6	12.1	15.7
Cohort size (millions):					
Natives	31.8	37.8	45.3	49.4	49.3
Immigrants	1.1	1.8	3.4	6.0	7.7
Age:					
Natives	42.8	41.4	40.5	42.1	43.6
Immigrants	44.0	42.2	41.3	41.6	43.4
Hourly wage:					
Natives	21.5	22.2	21.1	22.4	21.3
Immigrants	21.5	21.4	19.2	19.6	17.8
HS dropouts (%):					
Natives	39.5	22.9	10.9	7.1	5.1
Immigrants	48.5	40.5	30.6	29.3	27.4
HS graduates (%):					
Natives	33.4	36.3	32.4	38.8	35.5
Immigrants	20.7	20.9	21.6	26.7	27.1
Some college (%):					
Natives	11.6	17.4	28.9	23.7	25.5
Immigrants	10.9	12.1	18.3	13.3	13.2
College graduates (%):					
Natives	15.4	23.4	27.8	30.5	33.9
Immigrants	19.8	26.6	29.4	30.7	32.3

*Note:* The statistics are based on the sample of male immigrants aged 25-64 reporting positive income (not living in group quarters) in the United States from the Census 1970, 1980, 1990, 2000, and the pooled ACS 2009-2011 (indicated as 2010). Observations are weighted by the personal weights obtained from IPUMS, rescaled by annual hours worked.