Rethinking the Gains from Immigration: Theory and Evidence from the U.S.

Gianmarco I.P. Ottaviano, (Universita' di Bologna and CEPR)

Giovanni Peri, (University of California, Davis and NBER)*

January, 2006

Abstract

The standard empirical analysis of immigration, based on a simple labor demand and labor supply framework, has emphasized the negative impact of foreign born workers on the average wage of U.S.-born workers (particularly of those without a high school degree). A precise assessment of the average and relative effects of immigrants on U.S. wages, however, needs to consider labor as a differentiated input in production. Workers of different educational and experience levels are employed in different occupations and are therefore imperfectly substitutable. When taking this approach, one realizes that foreign-born workers are "complements" of U.S.-born workers in two ways. First, foreign-born residents are relatively abundant in the educational groups in which natives are scarce. Second, their choice of occupations for given education and experience attainments is quite different from that of natives. This implies that U.S.- and foreign-born workers with similar education and experience levels are imperfectly substitutable. Accounting carefully for these complementarities and for the adjustment of physical capital induced by immigration, the conventional finding of immigration's impact on native wages is turned on its head: overall immigration over the 1980-2000 period significantly increased the average wages of U.S.-born workers (by around 2%). Considering its distribution across workers, such an effect was positive for the wage of all native workers with at least a high school degree (88% of the labor force in year 2000), while it was null to moderately negative for the wages of natives without a high school degree.

Key Words: Foreign-Born, Skill Complementarities, Wages, Gains from Migration.

JEL Codes: F22, J61, J31.

*Gianmarco I.P. Ottaviano, Department of Economics, University of Bologna, Strada Maggiore 45, 40125 Bologna, Italy. Email: ottavian@economia.unibo.it. Giovanni Peri, Department of Economics, UC Davis, One Shields Avenue, Davis, CA 95616. Email: gperi@ucdavis.edu. We thank Joshua Aizenman, David Card, Kenneth Chay, Larry Katz, Michele Tertilt, Giorgio Topa, participants to seminars in UC Berkeley, Stanford University, UC Santa Cruz, the Philadelphia Fed, the New York Fed and three anonymous referees for very helpful comments and suggestions. Benjamin Mandel provided excellent assistance in the editing of the paper. Errors are ours.

1 Introduction

During the last three decades the United States has experienced a remarkable surge in immigration. As documented in Table 1, the share of foreign-born workers in total employment has steadily grown from 2.6% in 1970 to 13.2% in 2003.[1] Parallel to this surge, the debate about the economic effect of immigrants on U.S. natives has gained momentum both inside and outside of academia. Spurring the debate, a large body of empirical work focused on the effect of immigrants on the wages of natives has provided a mixed set of results. Ten years ago an influential survey by Friedberg and Hunt (1995) summarized the literature concluding that, "the effect of immigration on the labor market outcomes of natives is small." Since then, a number of studies have re-examined the issue refining the estimates by accounting for important problems related to the endogeneity of immigrant inflow and the internal migration of U.S. workers. However, even with more accurate and sophisticated estimates at hand, a consensus has yet to be reached as some economists identify only small effects of immigration (Card, 2001) while others find large negative effects (Borjas, Friedman and Katz, 1997).[2] This negative view has been recently supported by an influential work (Borjas, 2003), based on updated national data from five decennial U.S. censuses (1960-2000) and a convincing empirical approach. The work argues that due to immigration over the period 1980-2000, U.S. workers lost, on average, about 3% of the real value of their wages; the loss reaches almost 9% for native workers without a high school degree (Borjas, 2003, Table IX, page 1369).

Our paper takes a fresh look at the overall issue. The key idea is that the aggregate effects of immigration should be measured within a *general equilibrium* framework. This has two main implications that cast a shadow of doubt on the aggregate relevance of most existing studies. First, while acknowledging that in principle "[im]migrants may complement some native factors in production... and overall welfare may rise" (Friedberg and Hunt, 1995, page 23), most studies thus far have only focused on the partial effects of immigrants on the wages of those native workers who are their closest substitutes (i.e. within the same occupation, education-experience or skill groups). By modeling labor as a differentiated input in general equilibrium, we enlarge the picture to better capture the effects of immigration within and between different groups. This is important since, in the presence of differentiated labor, the inflow of immigrants belonging to a certain group can be expected to have asymmetric impacts on the wages of different native groups: a negative impact on groups with substitutable characteristics and a positive effect on groups with complementary characteristics. An accurate measurement of the overall effect of immigration on native wages should, therefore, account for both the distribution of immigrants across groups and their substitutability with native workers between (and within) groups. In

[1] While remarkable, such rapid increases are not unprecedented for the U.S. Large inflows from Europe during the period 1880-1910 brought the percentage of foreign-born very close to 15% in the year 1910, and previous episodes of very intense immigration (e.g. 1.5 million Irish immigrants between 1845 and 1854, in the wake of a great famine) caused similar surges.

[2] We are aware of only one paper, Friedberg (2001), that finds a positive *partial* effect of immigration on native wages. In most cases, however, that effect is not significant.

particular, after controlling for occupation, education-experience or skill, the usual assumption that foreign- and U.S.-born workers are perfect substitutes seems intuitively questionable and unnecessary. After all, a Chinese cook, an Italian tailor, a French hair-dresser, a Belgian baker or a Brazilian guitarist produce services that are differentiated from those of their U.S.-native counterparts in their style, taste, quality, and design, just as the talent of Indian-born engineers or German-born physicists may be complementary to (and hard to replace by) those of natives. Be it because immigrants are a selected and generally talented group, or because they have some culture-specific skills, or because they differ in their preferences so that they tend to choose a different set of occupations (as we document below), it seems reasonable to allow them to be imperfect substitutes for natives even within an education-experience group and to let the data estimate the corresponding elasticities of substitution.

The second implication of our general equilibrium approach is a more careful consideration of the role of physical capital. As physical capital complements labor, it is important to account for its response to immigration, especially when evaluating the impact of immigration on wages in the long run (i.e. over one or more decades). Specifically, we assume that physical capital, rather than being given (as routinely assumed by the existing literature), accumulates endogenously instead. Hence, capital responds such that its rate of return is held constant. This assumption is easily derived from any standard long-run open or closed economy model. As we will see, it is also supported by the evidence showing that the behavior of the real return to capital over the period 1960-2000 contrasts starkly with both the assumption of a constant capital stock during each decade of observation and even the hypothesis that physical capital adjusts slowly to immigration. Rather, it is consistent with fast adjustment of the capital stock and constant long-run returns.

The outcome is a modeling strategy that, building on Borjas (2003), delivers a richer (though still parsimonious) framework based on an aggregate production function that combines many different types of labor with physical capital. From such a function we derive the demand for each type of labor, whose careful estimation allows us to produce a general equilibrium measure of the impact of immigrants on the average wage of U.S. natives, and in particular, on the wage of each type of native worker. The important and novel result is that, once we account for general equilibrium effects, we turn the commonly estimated negative effect of immigrants on the wages of natives on its head. Considering the period 1980-2000, we find that the average U.S. worker has experienced an increase of 2% in the real value of her wage because of immigration. At the same time, we find that college educated and high school educated natives are those who gained most from immigration (2.4% to 2.5%) while high school dropouts did not gain but did not lose much either (-0.4% to 0%)[3].

While our results may appear surprising and, at first, hard to reconcile with a supply and demand model (an increase in labor supply should not increase wages!), the logic behind them is very simple. Consider a standard

[3] These numbers are from Table 10 below.

constant returns to scale aggregate technology using differentiated labor and capital as inputs. Assume an immigration flow that increases the supply of a certain group of workers (defined by occupation, education-experience or skill). There are three *partial effects*. First, the marginal productivity of workers within the same group falls and this puts downward pressure on their real wages. Second, the marginal productivity of workers in other groups increases and this puts upward pressure on their real wages. Third, the marginal productivity of capital increases. This raises the real return to capital and fosters its accumulation, which in turn ends up increasing the productivity of labor and real wages. While the debate on immigration has so far focused on the first effect, our general equilibrium approach also highlights the other two effects. In line with the state-of-the-art, we do find a negative partial effect of immigrants on natives within the same group. We also find, however, that such a negative effect is dominated on average by the two other positive effects. Thus, there is no contradiction between our findings and the related literature as existing partial estimates are simply nested within our general equilibrium framework.

The remainder of the paper is organized as follows. Section 2 summarizes the relevant literature. Section 3 introduces the aggregate production function, derives the demand for each type of labor and identifies the key parameters for calculating the elasticity of native wages to the inflow of immigrants. This section also makes explicit the treatment of physical capital and its implications. Section 4 presents the data and the key estimates of the relevant elasticities. Using those estimates, Section 5 evaluates the effect of immigration on the wages of U.S. natives. Section 6 concludes the paper.

2 Review of the Literature

There is a long list of contributions in the literature dealing with the impact of immigrants on the wages of natives. We can do only partial justice to it in this section. In order to selectively review some of the relevant works it is helpful to clarify what question we ask in this paper. The question is: What is the impact of immigration on the productivity (wage) of workers born in the United States? The question really has two parts. The first is imbued with a "macro" flavor: Does the inflow of foreign born workers have a positive or negative net effect on the average productivity and income of U.S.-born residents? This question requires that we aggregate the wages of quite heterogeneous U.S. workers. The second question is more "micro" in focus: How are the gains and losses from immigration distributed across U.S.-born workers with different levels of education (and experience), and between labor and physical capital? The consensus emerging from the literature is that the first (macro) effect is rather small. Quantifications of this effect thus far (Borjas, 1995) imply that the sum total of all foreign-born workers accounts for a mere 0.1% increase in the average income going to labor and capital of U.S.-born residents. Therefore, the argument goes, one can neglect this small macro (average) effect and concentrate solely on the second question dealing with the distributional effects of immigration. Moreover, as immigrants are normally endowed with little physical capital (since few can transport their private homes or enterprises into the U.S.) most of the literature represents immigration as an increase in labor supply with a given capital stock (Borjas, 1995, 2003), and so readily finds a negative impact of immigration on average wages and a positive impact of immigration on the return to capital (due to complementarities between the two factors). Our reading of the literature, however, suggests that the "macro" aspect of the issue (related to average income and average wage) has been analyzed much more superficially than the "micro" aspect. Most of the recent debate has focused on the effects of immigration on the *relative* wages of more and less educated U.S.-born workers. Some economists argue for a large relative impact adverse to less educated workers (Borjas, 1994, 1999, 2003; Borjas, Freeman and Katz, 1997), while others favor a smaller, possibly insignificant, effect (Butcher and Card, 1991; Card, 1990; Card, 2001; Friedberg 2001; Lewis, 2003; National Research Council, 1997).

The size and significance of the estimated relative wage effects from immigration remain controversial, and possibly depend at least in part on the use of local versus national data. The present article uses a framework from which both the "macro" (average) and the "micro" (distributional) effects of immigration can be derived. We argue that only within such a framework, based on the aggregate production function and general equilibrium outcomes, can one measure and discuss either of these effects. To strengthen our point, we follow the less controversial empirical approach employed by Borjas (2003) that uses national (rather than local) data and instrumental variable (rather than OLS) methods in performing the estimations. This approach avoids the problems arising from internal migration of natives and from the endogenous choice of location when using metropolitan or state data[4].

The modern analysis of the effects of immigrant inflows on the wages of natives began with studies that treated the foreign-born simply as a single homogeneous group of workers (Grossman, 1982; Altonji and Card, 1991), imperfectly substitutable with U.S.-born workers (possibly divisible into sub-groups). A number of studies on the relative supply of skills and relative wages of U.S.-born workers made clear, however, that workers with different levels of schooling and experience are better considered as imperfectly substitutable factors (Katz and Murphy, 1992; Welsh, 1979; Card and Lemieux, 2001). As a consequence, more recent analysis has been carried out partitioning workers among imperfectly substitutable groups (by education and experience) while assuming perfect substitution of native and foreign-born workers within each group (Borjas, 2003). This article combines the two approaches in the sense that both can be seen as special cases nested in our more general framework. Specifically, we assume the existence of an aggregate production function that combines workers and physical capital, while using education, experience and place of origin (U.S. versus elsewhere) to categorize imperfectly substitutable groups. Following Borjas (2003), we choose a constant elasticity of substitution (CES) technology

[4] See Borjas, Freeman and Katz (1997) for a discussion.

and we partition the two groups of U.S.- and foreign-born workers across eight experience levels and four educational attainment classes. This allows for the imperfect substitutability of individuals between different country origins and different education-experience levels. Imperfect substitutability may arise from different abilities, occupational choices or unobserved characteristics of workers. Within this framework we estimate three sets of elasticities: (i) between country origins within education-experience groups; (ii) between experience levels within education groups; (iii) between education groups. There is very scant literature estimating the first set of elasticity parameters. The only work we are aware of is Jaeger (1996) which only uses 1980-1990 metropolitan data and whose estimates may be susceptible to attenuation bias and endogeneity problems related to the use of local data. The other two sets of elasticities (between experience and between education groups) have been estimated in several studies (Card and Lemieux, 2001; Katz and Murphy, 1992; Angrist, 1995; Ciccone and Peri, 2005), which provide us with benchmark measures to check the robustness of our calculated effects.

As for physical capital, we explicitly consider its contribution to production and treat its accumulation as endogenously driven by market forces that equalize real returns to capital in the long run. This is an important departure from the literature, which has not paid much attention to the response of physical capital to immigration. When evaluating the distributional effects of immigration, the prevalent assumption has been that of a fixed capital stock (Borjas, 1995; Borjas, 2003). Some results obtained using both fixed and flexible capital stock are nonetheless available (Borjas, Freeman and Katz, 1997; Borjas and Katz, 2005).

Finally, as mentioned earlier, several studies on the *relative* wage effects of immigrants have analyzed local data (metropolitan areas) accounting for the internal migration response of U.S. natives (Card, 2001; Card and Di Nardo, 2000; Lewis, 2003) and correcting for the endogeneity of immigrant location choice (both factors would cause an attenuation bias in the estimates). These studies find a small negative partial effect of immigrants on wages. In the same vein, our recent work (Ottaviano and Peri, 2005a, 2005b, 2006) has pointed out a positive effect of immigration on the average wage of U.S. natives across U.S. metropolitan areas. This positive and significant effect survived 2SLS estimation, using instruments that should be exogenous to city-specific unobservable productivity shocks.[5] The complementarities in production illustrated at the national level in the next section could also be at work at the city level. Accordingly, they could be used to reconcile the negative partial (relative) effects estimated on national data with the positive average effect estimated on local data in our previous studies.[6]

[5] We build the instrumental variables by using the initial share of foreign-born workers in a city, grouped by country of origin, and attributing to each group the average immigration rate for that nationality during each decade in the period (1970-2000). First introduced by Card (2001), this instrument is correlated with actual immigration in the metropolitan area if new immigrants tend to settle prevalently where fellow countrymen already live.

[6] The city model is developed in greater detail in Ottaviano and Peri (2005b).

3 Aggregate Production and Labor Demand

To evaluate the effects of immigrants on the wages of natives when workers differ in terms of education and experience, we need a model of how their marginal productivity change in response to changes in the supply of different types of labor. In the macro and growth literature, a simple and popular way of doing this is to assume an aggregate production function in which aggregate output (the final good) is produced using a combination of physical capital and different types of labor. Following Borjas (2003) and Card and Lemieux (2001), we choose a nested CES production function, in which physical capital and different types of labor are combined to produce output. Labor types are grouped according to education and experience characteristics; experience groups are nested within educational groups, that are in turn nested into a labor composite. U.S.-born and foreign-born workers are allowed a further degree of imperfect substitutability even when they have the same education and experience. The production function we use is given by the following expression:

$$Y = A\widetilde{C}^{\alpha}K^{1-\alpha} \tag{1}$$

where Y is aggregate output, A is total factor productivity (TFP), K is physical capital, $\widetilde{C}$ is the CES labor aggregate described below, and $\alpha \in (0,1)$ is the income share of labor. The production function exhibits constant returns to scale (CRS) and is a Cobb-Douglas combination of capital K and labor $\widetilde{C}$. Such a functional form is widely used in the macro-growth literature and is supported by the empirical observation that the share of income going to labor, α, is constant in the long run and across countries (Kaldor, 1961; Gollin, 2002). The labor aggregate $\widetilde{C}$ is defined as:

$$\widetilde{C} = \left[\sum_{k=1}^{4}\left(\frac{C_k}{\tau_k}\right)^{\frac{\delta-1}{\delta}}\right]^{\frac{\delta}{\delta-1}} \tag{2}$$

where C_k is an aggregate measure of labor with educational level k; $\frac{1}{\tau_k}$ are education-specific productivity levels (we impose the standardization $\sum_k \left(\frac{1}{\tau_k}\right)^{\frac{\delta-1}{\delta}} = 1$ as any common multiplying factor can be absorbed by A). As standard in the labor literature, we group educational achievements into four categories: High School Dropouts (denoted as HSD) , High School Graduates (HSG), College Dropouts (COD) and College Graduates (COG), so that $k = \{HSD, HSG, COD, COG\}$. The parameter $\delta > 0$ measures the elasticity of substitution between workers with different educational achievements. Within each educational group we assume that workers with different experience levels are also imperfect substitutes. In particular, following the specification used in Card and Lemieux (2001), we write:

$$\frac{C_k}{\tau_k} = \left[\sum_{j=1}^{8}\left(\frac{C_{kj}}{\tau_{kj}}\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{3}$$

where j is an index spanning experience intervals of five years between 0 and 40 years, so that $j = 1$ captures workers with $0-5$ years of experience, $j = 2$ those with $6-10$ years, and so on. The parameter $\theta > 0$ measures the elasticity of substitution between workers in the same education group but with different experience levels and $\frac{1}{\tau_{kj}}$ are experience-specific productivity level (standardized so that $\sum_j \left(\frac{1}{\tau_{kj}}\right)^{\frac{\theta-1}{\theta}} = 1$ for each k) . As we expect workers within an education group to be closer substitutes than workers across different education groups, our prior (consistent with the findings of the literature) is that $\theta > \delta$. Finally, distinct from most of the literature, we define $\frac{C_{kj}}{\tau_{kj}}$ as a CES aggregate of home-born and foreign-born workers. Denoting by H_{kj} and F_{kj} the number of workers with education k and experience j who are, respectively, home-born and foreign-born, and by $\sigma_k > 0$ the elasticity of substitution between them, our assumption is that:

$$\frac{C_{kj}}{\tau_{kj}} = \left[\left(\frac{H_{kj}}{\tau_{Hkj}}\right)^{\frac{\sigma_k-1}{\sigma_k}} + \left(\frac{F_{kj}}{\tau_{Fkj}}\right)^{\frac{\sigma_k-1}{\sigma_k}}\right]^{\frac{\sigma_k}{\sigma_k-1}} \tag{4}$$

The underlying idea is that foreign-born workers receive part of their education abroad, they are often raised with different references and they are likely to have different abilities pertaining to language, quantitative skills, relational skills and so on. These characteristics are likely to affect their choices of occupation and their abilities in the labor force, therefore they should be differentiated enough to be treated as imperfect substitutes for U.S.-born workers, even within the same education and experience group. As we expect workers within the same education and experience group to be closer substitutes than workers across different education and experience groups, our working hypothesis is that $\sigma_k > \theta$. We analyze this issue in detail in Section 4 below. Ultimately we allow the empirical analysis to reveal whether U.S.-born workers and foreign-born workers within the same education and experience group are perfect substitutes ($\sigma_k = \infty$) or not.[7] In so doing, as indicated by the subscript k, we allow the elasticity of substitution between U.S.- and foreign-born workers to differ across education groups (more on this below). Finally, the terms $1/\tau_{Fkj}$ and $1/\tau_{Hkj}$ measure the specific productivity levels of foreign- and home-born workers and are also standardized so that $\frac{1}{\tau_{Hkj}}^{\frac{\sigma k-1}{\sigma k}} + \frac{1}{\tau_{Fkj}}^{\frac{\sigma k-1}{\sigma k}} = 1$.

3.1 Physical Capital

Since we use decennial census data to estimate the parameters in the production function and to evaluate the impact of immigration on U.S. wages, it seems reasonable to treat physical capital as endogenously accumulated rather than fixed. Given (1), a fixed stock of capital would imply that any increase in labor supply due to immigration decreases the aggregate capital-output ratio K/Y, increases the marginal productivity of capital and therefore its real return. On the other hand, either assuming international capital mobility or capital accumulation, along the long run balanced growth path of the Ramsey (1928) or Solow (1956) models, the real

[7] The standard assumption in the literature has been, so far, to impose that $C_{kj} = H_{kj} + F_{kj}$, i.e. that once we control for education and experience, foreign-born and natives are workers of identical type.

interest rate r and the aggregate capital-output ratio K/Y are both constant. This assertion is supported in the data as the real return to capital in the U.S. does not exhibit any trend in the long run (Kaldor, 1961). In particular, this is also true for our period of observation 1960-2000 as depicted in Figure 1, where the real interest rate is measured as the nominal interest rate minus the realized inflation rate. Figure 1 is complemented by Table 2, whose right hand column reports the changes in real interest rate by decade. The changes are large and negative in the 1960s and 1970s, large and positive in the 1980s, and almost null in the 1990s. On the other hand, the left hand column in the table shows that the immigration rate exhibits a steady tendency to grow between 1960 and 2000. The lack of positive correlation between real interest and immigration rates is incompatible with a fixed stock of capital. It is, instead, compatible with a fast endogenous reaction of the capital stock to changing labor supply. Consequently, we can safely assume that physical capital adjusts in order to maintain a constant interest rate, which allows us to express the capital stock as a function of A, r and $\widetilde{C}$. Substituting into the production function (1) to express output as a linear function of the labor composite:

$$Y = \left(\frac{1-\alpha}{r}\right)^{\frac{1-\alpha}{\alpha}} A^{\frac{1}{\alpha}}\widetilde{C} = \widehat{A}\widetilde{C} \tag{5}$$

where the factor $\widehat{A} = \left(\frac{1-\alpha}{r}\right)^{\frac{1-\alpha}{\alpha}} A^{\frac{1}{\alpha}}$ absorbs a constant and re-scales the TFP factor. Expression (5) shows that in the long run income per worker grows at a rate determined by exogenous technology A (as in any neoclassical growth model) and that the elasticity of income to the labor composite $\widetilde{C}$ is one. We are now ready to use (5) to calculate the long-run elasticities of wages to the supply of different kinds of workers.[8]

3.2 Effects of Immigration on Wages

The production function (5) can be used to calculate the demand functions for each type of labor at any point in time. After choosing output as numeraire good, in a competitive equilibrium the (natural logarithm of) the marginal productivity of U.S.-born workers in group k, j, equals (the natural logarithm of) their wage:

$$\ln w_{Hkjt} = \ln \widehat{A}_t + \frac{1}{\delta}\ln(\widetilde{C}_t) + \ln \Phi_{kt} - \left(\frac{1}{\delta} - \frac{1}{\theta}\right)\ln(C_{kt}) + \ln \Phi_{kjt} - \left(\frac{1}{\theta} - \frac{1}{\sigma_k}\right)\ln(C_{kjt}) + \ln \Phi_{Hkjt} - \frac{1}{\sigma_k}\ln(H_{kjt}) \tag{6}$$

where t is the time index. The term Φ_{kt} is equal to $\left(\frac{1}{\tau_{kt}}\right)^{\frac{1}{\delta}+\frac{1}{\theta}}$, Φ_{kjt} is equal to $\left(\frac{1}{\tau_{kjt}}\right)^{\frac{1}{\theta}+\frac{1}{\sigma_k}}$ and Φ_{Hkjt} is equal to $\left(\frac{1}{\tau_{Hkjt}}\right)^{1-\frac{1}{\sigma_k}}$. We assume that the relative efficiency parameters $(\tau_{kt}, \tau_{kjt}, \tau_{kjHt})$ as well as $\widehat{A}_t$ and their evolution over time, t, depend on technological factors and therefore are independent from the supply of foreign-born.

[8] This highlights one important difference with Borjas (2003) who, in calculating the long-run elasticities of wages to inflows of immigrants over twenty years, assumes a constant stock of capital.

Let us define the change in the supply of foreign-born due to immigration between two censuses as $\Delta F_{kjt} = F_{kjt+10} - F_{kjt}$. The total number of native and foreign born workers with education k and experience j will be denoted as $L_{kjt} = H_{kjt} + F_{kjt}$. We can use the demand function (6) to derive the effect on native wages of an inflow of foreign born in any skill group. The overall impact of immigration on natives with education k and experience j can be decomposed in three effects that operate through C_{kj}, C_k and $\widetilde{C}$. First, a change in the supply of foreign-born workers with education k and experience j affects the wage of natives with identical education and experience by changing the terms C_{kj}, C_k and $\widetilde{C}$ in expression (6). Second, a change in the supply of foreign-born workers with education k and experience i affects the wage of natives with identical education k but different experience j by changing the terms C_k and $\widetilde{C}$. Third, a change in the supply of foreign-born workers with education l affects native workers with different education j only through a change in $\widetilde{C}$.

While the exact expressions of the three effects are derived in Appendix A, here we focus on the first effect. In particular, as a way to illustrate one main difference with the previous literature, we define below the impact of immigrants with education k and experience j on the wages of natives with identical education and experience keeping the aggregates C_k and $\widetilde{C}$ constant. This measures a *partial* or *relative* effect. Consistent with expression (6), such effects have been estimated in the existing literature by regressing the wage of natives $\ln(w_{Hkjt})$ on the total number of immigrants in the same group k, j (often expressed as a share of initial employment in that group $\Delta F_{kjt}/L_{kjt}$) in a panel across groups and time (Borjas, 2003). Controlling for period effects and education-by-period effects eliminates any variation that is due to changes in C_{kt} and $\widetilde{C}_t$, as these vary with time and with education over time. The resulting partial effect, expressed as the percentage variation of natives' wage in response to a percentage variation of foreign employment in the group, is given by the following expression:

$$\varepsilon_{kjt}^{partial} = \left| \frac{\Delta w_{Hkjt}/w_{Hkjt}}{\Delta F_{kjt}/L_{kjt}} \right|_{C_k, \widetilde{C} \text{ constant}} = \left[\left(\frac{1}{\sigma_k} - \frac{1}{\theta} \right) \left(\frac{s_{Fkjt}}{s_{kjt}} \right) \left(\frac{\varkappa_{kjt}}{\varkappa_{Fkjt}} \right) \right] \tag{7}$$

The variable s_{Fkjt} is the share of overall wages paid in year t to foreign workers in group k, j, namely $s_{Fkjt} = \frac{w_{Fkjt}F_{kjt}}{\sum_m \sum_i (w_{Fmit}F_{mit} + w_{Hmit}H_{mit})}$. The variable $\varkappa_{Fkjt}$ is the share of foreign-born workers k, j in total employment, namely $\varkappa_{Fkjt} = \frac{F_{kjt}}{\sum_m \sum_i (F_{mit} + H_{mit})}$. Analogously, $s_{kjt} = \frac{w_{Fkjt}F_{kjt} + w_{Hkjt}H_{kjt}}{\sum_m \sum_i (w_{Fmit}F_{mit} + w_{Hmit}H_{mit})}$ and $\varkappa_{kjt} = \frac{(F_{kjt} + H_{kjt})}{\sum_m \sum_i (F_{mit} + H_{mit})}$ are the shares of total wage bill and of total employment, respectively, in year t accounted for by all workers in group k, j.

By construction, the elasticity $\varepsilon_{kjt}^{partial}$ captures only the effect of immigration on native wages operating through the term $\left(\frac{1}{\theta} - \frac{1}{\sigma k}\right) \ln(C_{kjt})$ in (6). Under the standard assumption of the existing literature, within group k, j U.S.- and foreign-born workers are perfect substitutes ($\sigma_k = \infty$) and share the same efficiency ($\tau_{kjHt} = \tau_{kjFt}$ which implies $\frac{s_{Fkjt}}{s_{kjt}} = \frac{\varkappa_{Fkjt}}{\varkappa_{kjt}}$). Then, (7) simplifies to $\varepsilon_{kjt}^{partial} = -\frac{1}{\theta}$: the harder it is to substitute between workers with different levels of experience (i.e. the lower θ), the stronger is the negative impact that immigrants have on the wages of natives with similar educational and experience attainment. In the general case ($0 < \sigma_k < \infty$), $\varepsilon_{kjt}^{partial}$ is still negative but smaller in absolute value than $\frac{1}{\theta}$, the reason being that the negative wage effect of immigrants on natives is partly attenuated by their imperfect substitutability.

Using estimates of the parameters σ_k and θ and data on wages and employment, the *partial* elasticity $\varepsilon_{kjt}^{partial}$ can be easily calculated. The problem is that it does not provide any indication on the total effect of immigration on the wages of natives in group k, j. The reason is that, to calculate the total effect, we also need to account for the changes in C_{kt} and $\widetilde{C}_t$ as well as for the fact that immigration alters the supply of foreign-born workers in all other education and experience groups. Once we do so, the total effect of immigration on the wages of native workers in group k, j (expressed as an elasticity) is given by the following expression:

$$\varepsilon_{kjt}^{total} = \frac{\Delta w_{Hkjt}/w_{Hkjt}}{\Delta F_t/L_t} = \frac{\frac{1}{\delta}\sum_m\sum_i \frac{s_{Fmit}}{\varkappa_{Fkmt}}\frac{\Delta F_{mit}}{L_t} + \left(\frac{1}{\theta}-\frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right)\sum_i \frac{s_{Fkit}}{\varkappa_{Fkit}}\frac{\Delta F_{kit}}{L_t} + \left(\frac{1}{\sigma_k}-\frac{1}{\theta}\right)\left(\frac{1}{s_{kjt}}\right)\left(\frac{s_{Fkjt}}{\varkappa_{Fkjt}}\right)\frac{\Delta F_{kjt}}{L_t}}{\Delta F_t/L_t} \tag{8}$$

where the percentage change in wage $\Delta w_{Hkjt}/w_{Hkjt}$ is standardized by $\Delta F_t/L_t = \sum_m\sum_i \frac{\Delta F_{mit}}{L_t}$ which is the total inflow of foreign born ΔF_t measured as a share of initial total employment L_t.

It is easy to provide an intuition for each term in expression (8), by referring to the labor demand equation (6). The term $\frac{1}{\delta}\sum_m\sum_i \frac{s_{Fmit}}{\varkappa_{Fkmt}}\frac{\Delta F_{mit}}{L_t}$ is a positive total effect on the productivity of workers in group k, j due to the increase in supply of all types of labor. This effect operates through $\frac{1}{\delta}\ln(\widetilde{C}_t)$ in (6) which is positive for $\delta > 0$. The term $\left(\frac{1}{\theta}-\frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right)\sum_i \frac{s_{Fkit}}{\varkappa_{Fkit}}\frac{\Delta F_{kit}}{L_t}$ is the additional negative effect on productivity generated by the supply of immigrants within the same education group. As those immigrants are better substitutes for natives in group k, j due to similar education, they have an additional depressing effect on their wage. This effect operates through $\left(\frac{1}{\delta}-\frac{1}{\theta}\right)\ln(C_{kt})$ in (6) which is negative if $\theta > \delta$. Finally, the term $\left(\frac{1}{\sigma_k}-\frac{1}{\theta}\right)\left(\frac{1}{s_{kjt}}\right)\left(\frac{s_{Fkjt}}{\varkappa_{Fkjt}}\right)\frac{\Delta F_{kjt}}{L_t}$ is the additional negative effect due to the supply of immigrants with the same education and experience as natives in group k, j. This last effect operates through $\left(\frac{1}{\theta}-\frac{1}{\sigma k}\right)\ln(C_{kjt})$ in (6) and it is exactly the partial effect $\varepsilon_{kjt}^{partial}$ multiplied by $\Delta F_{kjt}/L_{kjt}$. Clearly, since the total effect aggregates the partial effect together with 40 other cross-effects (32 in the double summation and 8 in the single summation), $\varepsilon_{kjt}^{total}$ will be generally quite different from $\varepsilon_{kjt}^{partial}$. In fact, when immigration is large in groups with education and experience different from k and j, the effect $\varepsilon_{kjt}^{total}$ can be large and positive while $\varepsilon_{kjt}^{partial}$ is negative. We will show that this is indeed the case by calculating $\varepsilon_{kjt}^{total}$ from estimated values for σ_k, θ and δ, plus data on employment and salary.

Finally, by aggregating the total effect of immigration on the wages of all groups of natives, we can obtain the total effect of immigration on the average wage of U.S.-born workers. Defining the average in year t as $w_{Ht} = \sum \varkappa_{Fkjt} w_{Fkjt}$, the total effect of immigration on the average wage of natives evaluates to:

$$\varepsilon_t^{total} = \frac{\Delta \overline{w}_{Ht}/\overline{w}_{Ht}}{\Delta F_t/L_t} = \sum_k \sum_j s_{kjt} \frac{\Delta w_{Hkjt}/w_{Hkjt}}{\Delta F_t/L_t} \tag{9}$$

We refer to ε_t^{total} as the total elasticity of the average wage of natives to immigration and we will calculate it by using the values from expression (8) and data on the share of wages going to foreign-born workers in each group (s_{kjt}).

4 Parameter Estimates

4.1 Data Description and Preliminary Evidence

The data we use are from the integrated public use microdata samples (IPUMS) of the U.S. census (Ruggles et al, 2005) for the years 1960, 1970, 1980, 1990 and 2000. These data are based on the 1% PUMS samples for the years 1960 and 1970 and on the 5% state samples for the 1980-2000 census data. We consider people ages 17-65 not living in group quarters and who worked at least one week in the previous year earning a positive amount in salary income. We convert the current wages to constant wages (year 2000 $U.S.) using the CPI deflator across years. We also impose a homogeneous top-code for wages at 1.5 times the value of wages at the 98th percentile of the distribution. We define the four schooling groups using the variable that identifies the highest grade attended (called "higradeg" in IPUMS) for census 1960 to 1980 while we use the categorical variable (called "edu99" in IPUMS) for censuses 1990 and 2000. Years of experience are calculated using age and assuming that people without an high school degree enter the labor force at 17, people with high school degree enter at 19, people with some college enter at 21 and people with a college degree enter at 23. Finally, yearly wages are based on the variable salary and income wage (called "incwage" in IPUMS). Weekly wages are obtained dividing that value by the number of weeks worked. Hourly wages are calculated dividing weekly wages by the number of hours worked during the last week[9]. The status of "foreign-born" is given to those workers whose place of birth (variable "BPL") is not within the USA (or its territories overseas) and did not have U.S. citizenship at birth. The average wage for workers in a cell, (the variable $(w_x)_{kjt}$ for $x = \{H, F\}$, $k = \{HSD, HSG, COD, COG\}$ and $j = \{1, 2..., 8\}$) is calculated as the weighted average of individual wages in the cell using the individual weight ("perwt") assigned by the U.S. census. The total number of workers in each cell ($H_{kj}$and F_{kj}) is calculated as the weighted sum of workers belonging to that cell. These data allow us to construct the variables $\varkappa_{xkj}$ and s_{xkj}, the share of each group in the total wage bill and in total employment, as well as to estimate the parameters δ, θ, σ_k needed to calculate the elasticities $\varepsilon_{kjt}^{partial}$, $\varepsilon_{kjt}^{total}$and ε_t^{total}. Before proceeding with the econometric analysis let us show two sets of simple statistics that already suggest how

[9] To keep samples comparable across census years we use the categorical variables that measure weeks worked and hours worked. They are available each census year and are called "wkswork2" for weeks worked and "hrswork2" for hours worked. Individuals are assigned the median value of the variables in the interval.

foreign-born workers are not perfectly substitutable with U.S.-born ones but rather complement them in their distribution of education and skills.

Let us first consider the educational attainments of U.S.-born and foreign-born workers in year 2000. Figure 2 reports what percentage of workers is foreign-born in each of seven "schooling" groups, i.e. the *relative* presence of foreign-born in each group from the Census 2000. Proceeding from the left to the right side of Figure 2 the bars of the histogram indicate the percentage of foreign-born workers among the following groups: High School Dropouts, High School Graduates, College Dropouts, College Graduates, Masters, PhD's, and PhD's working in the fields of science and engineering. The horizontal line at 10.5% indicates what percentage of each group would be foreign-born if they were distributed proportionally to the native population across the groups. The actual distribution shows a clear "U-shape" of foreign-born educational attainments: foreign-born are relatively abundant among workers with low levels of education as well as among workers with high levels while they are under-represented in the intermediate schooling levels. Figure 3, on the other hand, shows the *absolute* distribution of U.S. native workers among the same schooling groups described above. Clearly, in absolute terms, the U.S. labor force is concentrated (60% of total) among the two intermediate groups (high school graduates and college dropouts). Only 12% of natives do not have a high school degree and the percentages of college graduates, masters and PhD's are respectively 18%, 7% and 3%. In summary, foreign-born workers are relatively abundant in those groups in which there are fewer natives (in absolute terms) and they are relatively scarce in those groups that have larger numbers of natives. The complementarity of educational attainments already suggests a potential benefit to U.S.-born workers through relative scarcity: the groups with intermediate schooling would gain while the high and low education groups would lose. Given the larger size of the intermediate groups in employment, the positive wage effect out-weighs the negative one in aggregate.

There is, however, a more interesting way in which foreign-born are imperfect substitutes for U.S.-born workers. Even considering workers who have identical measurable human capital (education and experience), foreign- and U.S.-born differ in several respects that are relevant to the labor market. First, immigrants are a selected group of their original populations and have skills, motivations and tastes that may set them apart from natives. Second, in manual and intellectual works they have culture-specific skills (e.g. cooking, crafting, opera singing, soccer playing). Third, and most important, due to portability of skills or historical accidents, foreign-born tend to choose different occupations than natives even for given education and experience. As services of different occupations are imperfectly substitutable, this would imply imperfect substitutability between natives and foreign-born.

Differences in the occupational choice between natives and foreign-born with same education and experience are illustrated in Table 3. Following Welch (1990) and Borjas (2003) we calculate the "index of congruence" in the choice of 472 occupations (from Census 2000 definitions) between the group of native workers and the group of foreign-born workers with the same education and experience levels. The index of congruence is calculated by constructing a vector of shares in each occupation for each group and computing the centered correlation coefficient between these vectors for the two groups. A value of the index equal to 1 implies an identical distribution of workers among occupations for the two groups, a value equal to -1 implies an exactly "complementary" distribution. From the top portion of Table 3 for high school dropouts (3A) to the bottom portion for college graduates (3D), the first column of each table reports the index of congruence between natives and foreign born in the same schooling and ten-year experience group (between 0 and 40 years). By way of comparison, the remaining columns report the indices of congruence between natives in different experience groups within the same education group. Three facts emerge that are worth emphasizing. First, the index of congruence between U.S.- and foreign-born with identical education and experience is always smaller than 0.75 and for some education-experience cells is as low as 0.5. This denotes differences in occupational choices. Second, looking at the average congruence between native and foreign born (last row and first column in each table) and comparing it to average congruence between natives with different experience levels (last row and second column in each table), we find that the first is always approximately equal to or smaller than the second. This implies that, from an occupational perspective, natives and foreign-born are not easier to substitute than U.S.-born with different experience levels. Given that an extensive literature shows imperfect substitutability between U.S. workers with different experience (Welch, 1979; Card and Lemieux, 2001), we would also expect a less than perfect degree of substitutability between natives and foreign-born with similar education and experience. Finally, within the group of college educated workers, there is the smallest degree of congruence in the choice of occupation between U.S.- and foreign-born. This suggests that the lowest degree of substitutability between foreign-born and U.S.-born workers may be reached in the educational group of college graduates. In light of these preliminary findings we can now approach the econometric estimation of the relevant elasticities of substitution.

4.2 Estimates of the Elasticities of substitution

4.2.1 Estimates of σ_k

The model developed in Section (3) provides us with the framework to estimate the parameters σ_k. Calculating the natural logarithm of the ratio of the wages of U.S.-born and foreign-born workers within the same group k, j we obtain the following relation:

$$\ln(w_{Hkjt}/w_{Fkjt}) = -\frac{1}{\sigma_k}\ln(H_{kjt}/F_{kjt}) - \frac{\sigma_k - 1}{\sigma_k}\ln(\tau_{Hkjt}/\tau_{Fkjt}) \tag{10}$$

which defines the relative labor demand for foreign and U.S.-born workers in group k, j. Equation (10) can be used to estimate the coefficient $\frac{1}{\sigma_k}$ (i.e. the elasticity of relative demand) as long as we identify a source of variation in relative supply $\ln(H_{kjt}/F_{kjt})$ that is independent of the variation of relative efficiency $\ln(\tau_{Hkjt}/\tau_{Fkjt})$.

Our estimation strategy works as follows. Due to technological reasons such as skill-biased technical change and increased international competition over the period 1960-2000, the profiles of the returns to education and to experience have changed differently across occupations. Accordingly, we allow relative efficiency to have a systematic component that may vary by education and experience over time and we control for education by year effects (D_{kt}) as well as experience by year effects (D_{jt}). Conditional on these controls, we assume that the decennial changes in foreign-born workers across experience-education cells (mostly due to new immigrants) constitute exogenous supply shocks uncorrelated with $\ln(\tau_{Hkjt}/\tau_{Fkjt})$ and hence can be used as instrument for $\ln(H_{kjt}/F_{kjt})$ to estimate the coefficient $\frac{1}{\sigma_k}$ consistently. Thus, using the census data from 1960 through 2000 we end up running the following regression:

$$\ln(w_{Hkjt}/w_{Fkjt}) = D_{kt} + D_{jt} - \frac{1}{\sigma_k}\ln(H_{kjt}/F_{kjt}) + u_{kjt} \tag{11}$$

using $\ln(1/F_{kjt})$ as an instrument for $\ln(H_{kjt}/F_{kjt})$ so that, once we control for D_{kt} and D_{jt}, the changes in supply of foreign-born workers specific to an education-experience cell are uncorrelated with the remaining variation of relative efficiencies u_{kjt}.[10]

In total we estimate the above equation for 160 observations (8 experience by 4 education groups by 5 census years) and include twenty D_{kt} and fourty D_{jt} fixed effects. The variables w_{Hkjt}, w_{Fkjt}, H_{kjt}, F_{kjt} are constructed as described in section 4.1 above. Table 4 reports the estimated values of $\frac{1}{\sigma_k}$ obtained using different samples, methods and definitions of wage. The estimates reported in the first row impose that σ_k is constant across education groups ($\overline{\sigma}$) while the following four rows allow that elasticity to be education-specific and report separately the estimates for the elasticity in each group. ($1/\sigma_{HSD}$, $1/\sigma_{HSG}$, $1/\sigma_{COD}$, and $1/\sigma_{COG}$). Specification 1 reports the OLS estimates using weekly wages and male workers to measure w_{Hkjt}, w_{Fkjt} and H_{kjt}, F_{kjt}. The reported standard errors are clustered by education-experience cells and each regression weights the observations by the employment in the cell. Specification 2 estimates $\frac{1}{\sigma_k}$ following the instrumental variable strategy described above and uses $\ln(1/F_{kjt})$ as an instrument. Specification 3 also follows an IV strategy, and uses the instrument $\ln(1/F_{kjt}^{new})$, where F_{kjt}^{new} is the number of immigrants who entered the country during the previous decade only (i.e. they were not recorded in the previous census). In trying to identify an exogenous source of variation in the relative supply of labor, new immigrants (F_{kjt}^{new}) should be the least affected by the domestic relative productivity changes, $\ln(\tau_{Hkjt}/\tau_{Fkjt})$, and hence the most exogenous instrumental variable. Indeed, the total number of foreign-born workers F_{kjt} includes also long-time residents (especially in the more

[10] We discuss the quality of $\ln(1/F_{kjt})$ as instrument with respect to alternative options in Section 4.2.1 below.

experienced groups) who may move back, retire or re-qualify as response to group-specific technological shocks and may introduce some endogeneity bias. On the other hand, $\ln(1/F_{kjt})$ is, in general, more correlated with $\ln(H_{kjt}/F_{kjt})$ than $\ln(1/F_{kjt}^{new})$ and the information on year of immigration is only available since census 1970, hence we have to restrict our sample to 1970-2000 when using the second instrument.

The comparison between the OLS and the IV estimates of the parameter $(1/\overline{\sigma})$ reveals the presence of a moderate downward OLS bias (i.e. a bias of $-\frac{1}{\sigma_k}$ towards 0), which is exactly what we would expect if the supply of native workers H_{kjt} had a positive correlation with u_{kjt}. The demand elasticity $\frac{1}{\sigma_k}$ is estimated using IV methods, with values of 0.25 (specification 2) and 0.28 (specification 3), rather than 0.18 (the OLS estimate, Specification 1). This implies an elasticity of substitution between U.S.- and foreign-born workers of around 4. The results from the first stage regressions (coefficients and F-test of exclusion of instrument) reported in the last two rows show that the shocks to the supply of foreign-born (total and newly immigrated) shift the relative supply $\ln(H_{kjt}/F_{kjt})$ significantly. The F-test of exclusion of the instrument from the first stage always reject the exclusion at the 1% confidence level, and while the F-statistic is occasionally below 10 (often taken as the boundary value for weak instrument) it is never below 9. When we allow different elasticities of substitution between U.S.- and foreign-born workers across education groups (rows 2 to 5), two patterns emerge. First, the estimates of the relative demand elasticities are, in general, larger for the two extreme groups ($1/\sigma_{HSD}$ and $1/\sigma_{COG}$) for which they range between 0.18 and 0.32 than for the two intermediate ones ($1/\sigma_{HSG}$ and $1/\sigma_{COD}$) for which they range between 0.12 and 0.18. At the same time, however, the IV estimates, especially those in Specification 3, become less precise. Due to fewer degrees of freedom in estimating each of the four elasticities and to a weaker correlation of the instrument with the explanatory variable within each education group, the standard errors increase. For the parameters of the intermediate schooling groups ($1/\sigma_{HSG}$ and $1/\sigma_{COD}$), they could be as large as 0.2. Specifications 4 and 5 use all workers to calculate wages and employment and to perform IV estimation using $\ln(1/F_{kjt}^{new})$ or $\ln(1/F_{kjt}^{new})$ as instruments, respectively. The estimates (constrained and unconstrained) are very similar to the previous ones obtained using the sample of males only. Specifications 6 and 7 use yearly wages as measures of w_{Hkjt} and w_{Fkjt}. The elasticity of relative demand is estimated to be 0.45 when constrained to be the same across all education groups, whereas it is close to 0.4 for the two extreme education groups and between 0 and 0.3 for the two intermediate groups when left unconstrained. These estimates, larger and more imprecise than for the previous specifications, imply a possible adjustment of weeks worked (besides wages) in response to relative supply shifts, or may simply stem from the fact that yearly wages are a noisier measure of unit labor productivity. Finally, Specifications 8 and 9 show the results when we do not weight the cell by their employment. The elasticity of demand is close to 0.2 when constrained, whereas it is between 0.1 and 0.25 for the extreme groups and between 0 and 0.1 for the intermediate groups when left unconstrained.

While each single estimate is not extremely precise, the overall picture is quite clear. The constrained estimates are always larger than 0 and statistically significant, and mostly around the values 0.2-0.25. Within the unconstrained estimates, those for the two extreme groups ($1/\sigma_{HSD}$ and $1/\sigma_{COG}$) are mostly positive and significant (between 0.2 and 0.3) while those for the intermediate groups are generally small (between 0 and 0.15) and not always significant. Taken as a whole this evidence strongly support the hypothesis that foreign-born and U.S.-born workers in an education-experience cell are not perfect substitutes, especially within the groups of high school dropouts and college graduates (elasticity of substitution between 3 and 5).

Two comments are in order here. First, the pattern of lower substitutability in the two extreme educational groups (HSD and COG) seems to agree with a common sense intuition and, in part, with the preliminary evidence of Section 4.1. Among the highly educated, the foreign born choose occupations (in science and technology rather than in law and administration) and have creative, managerial, relational abilities that complement natives and are hard to substitute for. In a word, "talent" is specific and hard to substitute. On the other hand, among those who did not receive a formal education, some manual skills learned by doing (e.g. cooking, masonry, gardening) and some occupational choices that are avoided by natives (e.g. assistants of elderly people, taxi drivers) may also diversify the foreign born to a large extent. On the contrary, in the intermediate schooling groups there may be less scope for specific skills as clerical jobs or intermediate administrative positions require more standard skills and hence foreign born and natives are more easily substitutable. Lastly, the lowest substitutability is found among educational groups where the foreign born are relatively more abundant (see Figure 2). This feature should enhance the net beneficial effect of immigrants on the wages of natives.

IV Discussion: Estimates on Young Cohorts Only One reason for the lower significance of the unconstrained IV estimates in Table 4, especially those using new immigrants only as an instrument (Specifications 3, 5, 7 and 9), is that the group of recent immigrants is often a small percentage of total foreign-born (and even smaller of total employment) in several education-experience cells. Hence, its variation explains only a small fraction of fluctuations of the relative supply $\ln(H_{kjt}/F_{kjt})$. We can exploit, however, the experience (age) structure of new immigrants in order to identify the cells in which they are a larger fraction of total employment and hence have stronger correlation with changes of the relative supply. Figure 4 illustrates, pooling educational groups, the share of employment in each of the five-year experience intervals (0-40) represented by new immigrants (i.e. entered in the previous decade) for census data between 1970 and 2000. Clearly most new immigrants enter the country as young (or relatively young) workers, and they represent the highest share of employment in the young cohorts. For the cohorts with less than 20 years of experience immigrants represent sizable shares of employment (more than 5%) and large variations across groups and over decades are observed. For the cohorts above 20 years, new immigrants are never more than 4% of employment and not much variation is observed across groups and over decades. Assuming that the variation of immigrants in young cohorts identifies supply shocks that are larger and bear higher correlations with relative supply shocks, we could improve on the precision of our estimates by limiting our estimation to the groups of young workers with less than 20 years of experience. This is exactly what we do in Table 5, in which we reproduce the estimates of Table 4 after restricting the sample to the groups with less than 20 years of experience (4 groups for each educational attainment). Confirming our intuition the significance of the instruments as well as the precision of the estimates increase. Moreover, the point estimates of the elasticity of demand become somewhat larger, averaging 0.275 when constrained ($1/\overline{\sigma}$) and ranging between 0.2 and 0.4 for $1/\sigma_{HSD}$ and $1/\sigma_{COG}$ and between 0 and 0.2 for $1/\sigma_{HSG}$ and $1/\sigma_{COD}$ when left unconstrained. Overall the results obtained on the young cohorts confirm and strengthen our results on the imperfect substitutability between U.S.- and foreign-born workers.

4.2.2 Estimates of θ

Equation (11) has allowed us to estimate the parameter σ_k. We can also use it to infer the systematic component of the efficiency terms $\frac{1}{\tau_{Hkjt}}$ and $\frac{1}{\tau_{Fkjt}}$ that vary with education-time and experience-time. In particular, those terms can be obtained from the estimates of the fixed effects $\widehat{D}_{kt}$ and $\widehat{D}_{jt}$ as:

$$\left(\frac{1}{\widehat{\tau}_{Hkjt}}\right)^{\frac{\sigma_k-1}{\sigma_k}} = \frac{\exp(\widehat{D}_{kt})\exp(\widehat{D}_{jt})}{1+\exp(\widehat{D}_{kt})\exp(\widehat{D}_{jt})}, \left(\frac{1}{\widehat{\tau}_{Fkjt}}\right)^{\frac{\sigma_k-1}{\sigma_k}} = \frac{1}{1+\exp(\widehat{D}_{kt})\exp(\widehat{D}_{jt})} \tag{12}$$

where we have imposed the standardization that they add up to one. Using (12) we can construct the aggregate labor input $\frac{C_{kjt}}{\tau_{kjt}}$ in (4). Indeed, the production function (1) and marginal pricing imply the following relation between the compensation going to the labor input C_{kjt} and its supply:

$$\ln(W_{kjt}) = \ln \widehat{A}_t + \frac{1}{\delta}\ln(\widetilde{C}_t) - \left(\frac{1}{\delta}-\frac{1}{\theta}\right)\ln(\frac{1}{\tau_{kt}}) - \left(\frac{1}{\delta}-\frac{1}{\theta}\right)\ln(C_{kt}) + \left(1-\frac{1}{\theta}\right)\ln(\frac{1}{\tau_{kjt}}) + \left(1-\frac{1}{\theta}\right)\ln(C_{kjt}) \tag{13}$$

where $W_{kjt} = w_{Fkjt}F_{kjt} + w_{Hkjt}H_{kjt}$ is the total wage paid to workers in the education-experience group k, j and can be considered as the compensation to the composite input C_{kjt}. That variable is readily calculated using data on w_{Fkjt}, w_{Hkjt}, F_{kjt} and H_{kjt}.

Equation (13) provides the basis to estimate the parameter $\frac{1}{\theta}$ that measures the elasticity of relative demand for workers with identical education and different experience. Empirical implementation is achieved by rewriting it as:

$$\ln(W_{kjt}) = D_t + D_{kt} + D_{kj} + \left(1-\frac{1}{\theta}\right)\ln(C_{kjt}) + e_{kjt} \tag{14}$$

and running it on 1970-2000 data. Four time fixed effects D_t control for the variation of $\ln \widehat{A}_t + \frac{1}{\delta}\ln(\widetilde{C}_t)$, twenty time by education fixed effects D_{kt} control for the variation of $-\left(\frac{1}{\delta}-\frac{1}{\theta}\right)\ln(\frac{1}{\tau_{kt}}) - \left(\frac{1}{\delta}-\frac{1}{\theta}\right)\ln(C_{kt})$. Finally, we assume that the efficiency term $\ln(\frac{1}{\tau_{kjt}})$ has a systematic component across education and experience groups that does not vary over time and we capture it by thirty two education by experience fixed effects D_{kj}. Conditional on these effects any further fluctuation of the term $\ln(\frac{1}{\tau_{kjt}})$ is assumed to be a zero-mean error e_{kjt}, uncorrelated with the changes in supply of newly immigrated foreign born. We use an IV estimate and we instrument the aggregate total supply of $\ln(C_{kjt})$ with $\ln(F_{kjt}^{new})$, which correlates with the part of $\ln(C_{kjt})$ made of foreign-born workers. Accordingly, the estimated coefficient on the variable $\ln(C_{kjt})$ is a consistent estimate of $1 - \frac{1}{\theta}$.

Table 6 reports the estimates and standard errors of $\frac{1}{\theta}$ obtained using the aforementioned procedure. For robustness purposes we have estimated the elasticity $\frac{1}{\theta}$ using different definitions of wage (weekly, yearly and hourly in the first, second and third row respectively), different samples (males in specification 1, 3, 5 and 7 or all workers in specification 2, 4, 6 and 8), and different parameters estimates of $\overline{\sigma}$ spanning the range obtained in Tables 4 and 5. Lastly, we have produced estimates (Specifications 7 and 8) by constructing the aggregate input C_{kjt} by simply adding H_{kjt} and F_{kjt} (i.e. assuming an infinite $\overline{\sigma}$).

The stability of the estimates of $\frac{1}{\theta}$ is remarkable. All specifications produce a value between 0.20 and 0.34 with an average value of 0.25. This implies an average estimate of the parameter θ equal to 4. The choice of the wage definition and the choice of the elasticity $\overline{\sigma}$ used to construct the variable $\ln(C_{kjt})$ do not seem to make a relevant difference in the parameter's estimates. In particular the estimates are little affected by the choice of $\overline{\sigma}$ to the extent that even the unrealistic, though customary, value of $\overline{\sigma} = \infty$, still implies a relative wage elasticity between experience groups in the range between 0.21 and 0.32. As discussed in Section 3.2, when taken with reverse signs, the estimates in columns 7 and 8 represent the *partial* effect $\varepsilon_{kjt}^{partial}$ of immigrants on wages within an education-experience group assuming perfect substitutability between H_{kjt} and F_{kjt}. Our estimated values are consistent with the existing literature on these partial effects (Borjas, 2003) as well as with available estimates of $\frac{1}{\theta}$ surveyed in Section 4.3. However, as we will see, the fact that the imperfect substitutability between U.S.- and foreign-born workers in group k, j has little influence on the estimated value of $\frac{1}{\theta}$ does not mean that it does not affect the estimated *total effects* of immigration on the wages of U.S. natives. This is why it is very important to take it into account.

4.2.3 Estimates of δ

Aggregating one level further, we can construct the CES composite $\frac{C_{kt}}{\tau_{kt}}$ by substituting the estimates from (14) into (3). In particular, the terms $\left(\frac{1}{\tau_{kj}}\right)^{\frac{\theta-1}{\theta}}$ are obtained from the estimates of the experience by education fixed effects, and are given by: $\left(\frac{1}{\tau_{kj}}\right)^{\frac{\theta-1}{\theta}} = \exp(D_{kj})/\sum_j \exp(D_{kj})$. The chosen production function together with marginal pricing then implies that the compensation going to the labor input C_{kt} and its supply satisfy the following expression:

$$\ln(W_{kt}) = \ln \widehat{A}_t + \frac{1}{\delta}\ln(\widetilde{C}_t) + \left(1 - \frac{1}{\delta}\right)\ln\left(\frac{1}{\tau_{kt}}\right) + \left(1 - \frac{1}{\delta}\right)\ln(C_{kt}) \qquad (15)$$

where $W_{kt} = \sum_j W_{kjt}$ is the total wage bill paid to workers in education group k, which can be seen as the compensation to C_{kt}. Following the same strategy as in the previous section, we use the above expression as the basis for the estimation of $\frac{1}{\delta}$. In so doing, we rewrite (15) as follows:

$$\ln(W_{kt}) = D_t + (Time\ Trend)_k + \left(1 - \frac{1}{\delta}\right) \ln(C_{kt}) + e_{kt} \tag{16}$$

which we implement using the 1960-2000 census data (or the 1970-2000 data when we rely on new immigrants as instrument). The time dummies D_t absorb the variation of the terms $\ln \widehat{A}_t + \frac{1}{\delta} \ln(\widetilde{C}_t)$. The terms $(Time\ Trend)_k$ are education-specific time trends. These control for the systematic component of the efficiency terms $\ln\left(\frac{1}{\tau_{kt}}\right)$ that are assumed to follow a time trend specific to each educational group. Conditional on these controls, any other change in efficiency is uncorrelated with the inflow of foreign born in the corresponding education groups. Hence, we can estimate the equation (16) using $\ln(F_{kt}) = \ln \sum_j F_{kjt}$ or $\ln(F_{kt}^{new}) = \ln \sum_j F_{kjt}^{new}$ as instruments for $\ln(C_{kt})$.

Table 7 reports the estimated values of $\frac{1}{\delta}$ and their standard errors. For robustness purposes, we have constructed the dependent variable C_{kt} using different combinations of the parameters $\overline{\sigma}$ and θ. The parameter $\overline{\sigma}$ has been chosen to be 5 (Specification 1 and 2) or 3 (Specification 3 and 4), which are values at the boundaries of the estimated range. The parameter θ has been set equal to ∞, 4 and 3 (different rows of Table 7). A value of infinity implies that workers of different experience levels are perfect substitutes, while 4 and 3 are values close to those estimated in Section 4.2.2. Before commenting on them, let us point out that our estimates are obtained using 16 observations only (four years by four education groups) and controlling for 8 extra effects (time dummies and time trends). Hence, at best, they provide a reference point for the value of the parameter $\frac{1}{\delta}$. Accordingly, our goal here is simply to show that they are compatible with those in the literature as surveyed in Section 4.3.

The average of the estimated values in Table 7 is 0.44, and most of the estimates are in the 0.4-0.5 range. Standard errors are around 0.15. This implies an estimate of the parameter δ of around 2.2 and henceforth we use 2 as a reference value. While no single estimate is particularly precise, the estimated values are overall quite stable and consistent with existing estimates, which mostly fall between 1.5 and 2. We consider this as further evidence supporting the validity of our method and the use of immigration as an exogenous shifter of labor supply.

4.3 Comparison with the Literature and Partial Effects of Immigration

Are our estimates of σ_k, θ and δ consistent with the existing literature? Starting with σ_k, an unpublished working paper by Jaeger (1996) provides the only previous estimates that we are aware of for the elasticity of substitution between native and foreign-born workers within a skill group. Jaeger considers imperfect substitutability between education groups and sexes, but does not consider experience as a relevant skill dimension. Estimates are based on data from 50 metropolitan areas, limited to 1980 and 1990 census data. As a consequence, those estimates are subject to the criticism that mobility of natives between cities may attenuate the impact of immigrants on wages (Borjas, Freeman and Katz, 1997). While Jaeger finds very small and insignificant estimates of the relative elasticities of wages ($1/\sigma$) for women, he finds that for men with a college degree the elasticity ($1/\sigma_{COG}$) is precisely estimated and close to 0.27, for high school dropouts and high school graduates ($1/\sigma_{HSD}$, $1/\sigma_{HSG}$) it is around 0.12-0.13, whereas it is insignificant for college dropouts ($1/\sigma_{COD} = 0$). Interestingly, these estimates are broadly consistent with our findings. In particular the estimate of $1/\sigma_{COG}$ is quite close to ours (the median is 0.26), while the estimate of $1/\sigma_{HSD}$ is lower (ours are around 0.24) but still consistent. Our estimates of $1/\sigma_{HSG}$ and $1/\sigma_{COD}$ are between 0 and 0.10, again consistent with the insignificant estimate of $1/\sigma_{COD}$ found in Jaeger. That paper, however, concludes that the complementarities between U.S.- and foreign-born workers are not large enough to deserve consideration. In particular, it falls short of analyzing the implication of those complementarities for the *total* effect of foreign born immigrants on average U.S. wages.

The parameter θ is estimated in Card and Lemieux (2001). Their preferred estimates of $1/\theta$ for the United States over the period 1970-1995 (as reported in their Table III, columns (1) and (2)) are between 0.2 and 0.26, thus implying a value of θ between 4 and 5. Borjas (2003) also produces an estimate of $1/\theta$. As we do, he uses immigration as a supply shifter but assumes perfects substitutability between U.S.- and foreign-born workers. His estimate is equal to 0.288 (with standard error 0.11), consistent with our findings. Recall, however, that, under the assumption of perfect substitutability between U.S. natives and foreign born (i.e. $\sigma = \infty$), the estimated value of $-1/\theta$ is a measure of the partial effect of immigrants on native wages within the same experience group while keeping the aggregate labor input constant (see definition (7)). Such effect is negative and significant in the previous literature as well as in our estimates, and it isolates the substitution effect of an inflow of workers on the most similar native workers. As it does not account for the complementarities across different groups, however, it cannot be used as a measure of the aggregate impact of immigration on native wages.

Finally, the parameter δ is certainly the most analyzed in the literature. Its key role in identifying the impact of increased educational attainment (as well as of skill-biased technological change) on wages made it the object of analysis in Katz and Murphy (1992), through Angrist (1995), Murphy et al (1998), Krusell et al (2000) and the recent work by Ciccone and Peri (2005). The estimates for that parameter range between 1.4 and 2. In particular, using national U.S. data from 1963 to 1987, Katz and Murphy (1992) obtain a value of 1.41. Using data from U.S. states from 1950 to 1990, Ciccone and Peri (2005) find a value of 1.5. Since our estimates of $1/\delta$ fall between 0.4 and 0.5, they imply a δ in the vicinity of 2, which is consistent with previous estimates. We use $\theta = 4$ and $\delta = 2$ as reference values in the next section, then provide robustness checks using $3 < \theta < 4$ and $1.5 < \delta < 2$, thereafter.

5 Total Effects of Immigration on Wages

With the estimated parameters at hand we can use (8) and (9) to calculate the total effect of immigration on wages. First we calculate the effect of the immigration during the most recent available decade (1990-2000) using the baseline estimates for our parameters. Then we show the sensitivity of our results to different parameter choices and we evaluate the impact of immigration in previous decades and over the two decade period between 1980 and 2000.

5.1 Calculated Effects, 1990-2000

The period 1990-2000 witnessed an inflow of foreign-born workers equal to 5.2% of the initial total employment in 1990. Therefore, using the notation established in Section 3.2, the value of $\Delta F_{1990}/L_{1990}$ was 5.2%. The distribution across educational groups of this inflow was as follows: $\Delta F_{HSD,1990}/L_{1990} = 2.3\%$, $\Delta F_{HSG,1990}/L_{1990} = 1.0\%$, $\Delta F_{COD,1990}/L_{1990} = 0.7\%$ and $\Delta F_{COG,1990}/L_{1990} = 1.2\%$. It is evident that, both in absolute terms and, much more, in relative terms, the two extreme groups received a larger share of immigrants. In its first to fourth rows, Table 8 shows the calculated percentage changes of (real) wages for each group of native workers due to such an inflow.[11] The last row reports the effect of immigration on the overall average wage of natives. Specifications from 1 to 6 adopt the assumptions and the estimates presented in the previous sections. In particular, Specifications from 1 to 3 use the same value $\overline{\sigma}$ of the elasticity of substitution between U.S.- and foreign-born workers for all educational groups. Specification 1 uses the median estimate of $\overline{\sigma}$ from the first rows of Tables 4 and 5, while Specification 2 uses a relatively high estimate of $\overline{\sigma}$ (obtained as the median estimate plus one median standard deviation of the estimates) and Specification 3 uses a relatively low one (obtained as the median estimate minus one median standard deviation of the estimates). Similarly, Specifications from 4 to 6 use the estimates from Tables 4 and 5 that allow σ_k to differ across education group. Specification 4 uses the median estimates, while Specifications 5 and 6 use high or low estimates (one median standard deviation above or below the median). The values of the parameters δ and θ are chosen to be equal to their reference values of 2 and 4, respectively. Specification 7 and 8 are included for comparison. In Specification 7, we assume that U.S.- and foreign-born workers are perfect substitutes in each group ($\overline{\sigma} = \infty$). Finally, Specification 8 assumes not only that perfect substitutability exists between U.S.- and foreign-born workers,

[11] Our model gives predictions for the effect on wages of each education-by-experience group. In the tables we averaged these effects within education groups to present the results more compactly.

but also that the stock of capital in the economy is fixed, rather than responding to changes in its return.[12] Both assumptions were rejected on several accounts in this study. They are, however, the standard ones in the literature and hence are used as benchmarks.

Let us focus, first, on Specifications from 1 to 6 starting with Specifications 1 and 4 as these are based on our most preferred parameter estimates. Remarkably the overall average real wage of natives receives a positive effect between 1.1% and 1.2% from immigration. Even more remarkably, all workers with at least a high school degree (who accounted for 88% of native labor force in 2000) gain, sometimes as much as 1.6% of their initial real wage. The group of native workers without a high school degree loses between 1.2% and 1.7% of its real wage. Indeed, for any of the values of σ_k within the range of reasonable estimates (see Specifications 2, 3, 5 and 6) our model predicts a significant average wage gain for natives. Such gains range from 0.9% to 1.6%. Again, all groups with at least a high school degree gain and, when the lowest elasticity estimates are considered, some groups gain as much as 1.8%. The group of high school dropouts generally loses. In the worst-case scenario (Specification 2) it loses as much as 2.4% of its initial wage, while in the best-case scenario (Specification 6) its wage is virtually unchanged. The overall results are quite striking: the vast majority of workers (88% of total native employment) gained significantly from immigration, often around 1.5% of the initial value of their wage; the overall average wage of natives increased by around 1%; only the minority of natives without high school degree (12% of total native employment) lost at most 2.4% of their wage but more likely close to 1.5%.

What is, perhaps, most remarkable is the comparison of these effects with those obtained in Specifications 7 and 8, which employ the oft-used assumptions of fixed capital and perfect substitutability between native and foreign-born workers. Specification 8 shows that, under both of those assumptions, the effect of immigration on the average wage is substantial and *negative* (−1.3%). Each schooling group experiences a wage loss and a native worker without a high school degree loses a whopping 7% of her initial wage. Clearly, as immigration increases labor supply, the assumption of fixed capital penalizes all workers, while the relative distribution of immigrants, not mitigated by their imperfect substitutability for natives, results in the very negative effect on the wage of workers with low educational levels. Specification 7 clarifies to what extent the two assumptions of fixed physical capital and perfect native-immigrant substitutability contribute to the very large differences between Specifications 1 and 8. It shows that, when physical capital adjusts endogenously but U.S.- and foreign-born are perfectly substitutable, the overall effect of immigration on the average wage is almost null (exactly half way between the negative 1.3% of Specification 8 and the positive 1.2% of Specification 1). The effects on workers with at least a high school degree are positive, falling between 0.5% and 1.1%, but smaller than the value 1.5% in Specification 1. With respect to 7% obtained in Specification 8, the loss of high school dropouts is reduced to 5.5% but it is still much larger than the 1.7% loss in Specification 1. To summarize, about half of

[12] The formulas needed to calculate the effect of immigration on wages under the assumption of a fixed capital stock are reported in Appendix B.

the difference between Specifications 1 and 8 is due to capital adjustment (incorporated in Specification 7) and the remaining half is due to the complementarity effects between U.S.- and foreign-born workers.

5.2 Robustness Checks and Alternative Periods

Table 9 shows some checks of the robustness (stability) of our calculated effects when we change the values of the parameters δ and θ. As the literature generally finds δ in the range 1.5 to 2, we use $\delta = 1.5$ in Specifications from 4 to 9. On the other hand, as our estimates of θ were mostly in the range between 3 and 4, we present the calculations for $\theta = 3$ in Specifications from 1 to 6. Columns 1, 4 and 7 use the median estimates for the constrained parameter $\overline{\sigma}$, while columns 2, 5 and 8 use the median estimates of the unconstrained parameters σ_k. For comparison, we also report the effects calculated for $\sigma = \infty$ in columns 3, 6 and 9. The positive effect of immigration on the average wage of natives as well as the large differences between the estimated scenario and the one with $\sigma = \infty$ are typical of all specifications and very robust to the choice of δ and θ. While a value of θ equal to 3 has only very marginal effects, the specifications using $\delta = 1.5$ exacerbates the disparity of effects between the groups (now high school dropouts lose 3.5% of their wage, while high school graduates and more educated workers gain between 1.6% and 1.9% using the median estimates of σ_k). However, even in this case, imperfect substitutability between native and foreign-born workers mitigates the wage dispersion effect of immigration, which with perfect substitutability makes the lowest education group lose 7.4% and the group of college dropouts gain 1.4% of their initial wages. Thus, in all cases, accounting for complementarities not only generates a positive significant average effect but also reduces the adverse wage-dispersion effect.

Finally, Table 10 shows the calculated effects of immigration using the median parameter estimates over the decades before the 1990's (1970-80 and 1980-90) as well as the overall effect for the 1980-2000 period. As our model accounts for capital adjustment in the long run, we can extend our calculations to longer time intervals with more reliability than the existing literature. Specifications from 1 to 4 show that, from 1970 to 1990, when, relative to the U.S. population, the inflow of immigrants was less biased towards high school dropouts, the within-group complementarity effect prevailed for all educational groups, so the effect of immigration is positive for each of them. However, since the percentages of immigrants were smaller, the average wage effects (as well as the effect on groups with more than high school education) were much smaller than in the 1990's: 0.6-0.7% rather then 1.2-1.3%. Turning to the last two decades taken as a whole (1980-2000), the overall inflow of immigrants was equal to 9.1% of the 1980 employment, Specifications 5 and 6 reveal that the corresponding effects are quite large. In particular, high school dropouts did not suffer any notable gain or loss in wages (0.2%); college dropouts gained 1.2% in real wage; high school graduates and college graduates gained about 2.5%. The overall average wage effect on native workers amounted to a positive 2%. This is quite a reversal from the previous literature that, during the same 1980-2000 period, reported a *loss* in native wages close to

3% of their real value (Borjas, 2003).

6 Conclusions

Immigration has complex economic and social implications on the host country. It may provide material costs and benefits for the native residents as well as psychological costs and benefits. Hardly any area of economic activity (from labor markets to the demand for consumption goods and services, from tax flows to the use of public goods) is left unaffected by the inflow of foreign workers.

An area in which economists have long been trying to provide theory and evidence is the measurement of the impact of immigrants on the productivity and the wages of native workers. The consensus view is that immigration has a negative impact on the real wages of native workers. This view is based on a model of demand for a homogeneous labor input holding all other inputs, such as physical capital, constant. We have argued that such a modeling strategy is reductive in two main respects. First, immigrants and natives differ in terms of skills, formal education, work experience and, additionally, innate and culture-specific abilities. This can be accounted for only by treating labor as a differentiated input. Second, no matter whether labor is homogeneous or differentiated, immigration increases labor supply. This raises the real return to physical capital, thus triggering its accumulation. We have shown that, after accounting for immigrant diversity and endogenous capital accumulation, the effects of immigration on the average wages of natives indeed turn positive and large. We take this result as strong encouragement for the careful modelling of diversity and complementarity among productive factors to fully account for the effects of immigration on the receiving economy.

References

Altonji, Joseph J. and David Card (1991) "The effects of Immigration on the Labor Market Outcomes of Less-Skilled Natives "in John M. Abowd and Richard Freeman eds, *Immigration, Trade and the Labor Market*, Chicago, the University of Chicago Press.

Angrist, Joshua (1995) "The Economic Returns to Schooling in the West Bank and Gaza Strip," *American Economic Review* 85 (1995), 1065-1087.

Borjas, George J. (1994) "The Economics of Immigration" *Journal of Economic Literature* 32, 1667-1717.

Borjas, George J. (1995) "The Economic Benefits from Immigration" *Journal of Economics Perspectives*, 9 (2), 3-22.

Borjas, George J. (1999) "Heaven's Door" Princeton University Press, Princeton and Oxford, 1999.

Borjas, George J. (2003) "The Labor Demand Curve is Downward Sloping: Reexamining the Impact of Immigration on the Labor Market" *Quarterly Journal of Economics*, CXVIII (4), 1335-1374.

Borjas, George J. and Katz Larry (2005) "The Evolution of the Mexican-Born workforce in the United States" NBER Working paper #11281, April 2005.

Borjas, George J., Freeman, Richard and Katz, Larry (1997) "How Much do Immigration and Trade Affect Labor Market Outcomes?" *Brookings Papers on Economic Activity*, 1997 (1), 1-90

Butcher, Katrin C. and Card, David (1991) "Immigration and Wages: Evidence from the 1980s" *American Economic Review*, Papers and Proceedings, 81 (2), 292-296.

Card, David (1990) "The Impact of the Mariel Boatlift on the Miami Labor Market" *Industrial and Labor Relation Review*, XLIII, 245-257.

Card, David (2001) "Immigrant Inflows, Native Outflows, and the Local labor Market Impacts of Higher Immigration" *Journal of Labor Economics*, XIX (2001), 22-64.

Card, David and Di Nardo, John (2000) "Do Immigrants Inflow Lead to Native Outflows?" NBER Working Paper n. 7578.

Card, David and Lemieux, Thomas (2001) "Can Falling Supply Explain the Rising Returns to College for Younger Men? A Cohort Based Analysis" *Quarterly Journal of Economics*, Vol. CXVI, pag. 705-746.

Ciccone, Antonio and Peri, Giovanni (2005) "Long-Run Substitutability between More and Less Educated Workers: Evidence from US States 1950-1990" *Review of Economics and Statistics*, Vol. 87, Issue 4.

Friedberg, Rachel and Jennifer Hunt (1995) "The Impact of Immigrants on Host Country Wages, Employment and Growth" *Journal of Economic Perspectives* No. 9, (2) page 23-44.

Friedberg, Rachel (2001) "The Impact of Mass Migration on the Israeli Labor Market" *Quarterly Journal of Economics*, vol. 116(4), 1373-1408.

Gollin, Douglas (2002) "Getting Income Shares Right," *Journal of Political Economy* 100, 458-474.

Grossman, Jean B. (1982) "The Substitutability of Natives and Immigrants in Production" *Review of Economics and Statistics*, 64, 596-603.

Jaeger, David (1996) "Skill Differences and the Effect of Immigrants on the Wages of Natives" U.S. Bureau of Labor Statistics Economic Working Paper #273.

Kaldor, Nicholas (1961) "Capital Accumulation and Economic Growth" in The Theory of Capital, ed. F. A. Lutz and D.C. Hague. New York, St. Martins.

Katz, Larry and Murphy, Kevin (1992) "Change in Relative Wages 1963-1987: Supply and Demand Factors," *Quarterly Journal of Economics* 107, 35-78.

Krusell, P., L. Ohanian, V. Rios-Rull and G. Violante (2000) "Capital-Skill Complementarity and inequality: A Macroeconomic Analysis," *Econometrica* 68, 1029-53.

Lewis, Ethan (2003) "Local Open Economies within the US. How do Industries respond to Immigration?" Federal Reserve Bank of Philadelphia, Working Paper 04-1.

Murphy, K., C. Riddle and P. Romer, "Wages, Skills and Technology in the United States and Canada," in General Purpose Technology and Economic Growth, E. Helpman (Editor), (Cambridge, MA, MIT Press 1998)

National Research Council (1997) "The New Americans: Economic, Demographic, and Fiscal Effects of Immigration" National Academy Press, Washington D.C..

Ottaviano, Gianmarco I.P. and Peri Giovanni (2005a) "Cities and Cultures" *Journal of Urban Economics*, Volume 58, Issue 2, Pages 304-307.

Ottaviano, Gianmarco I.P. and Peri Giovanni (2005b) "Rethinking the Gains from Immigration: Theory and Evidence from the U.S." NBER Working Paper, 11672.

Ottaviano, Gianmarco I.P. and Peri Giovanni (2006) "The Economic Value of Cultural Diversity: Evidence from U.S. cities" *Journal of Economic Geography*, Vol. 6, p. 9-44.

Ramsey, Frank.P. (1928) "A Mathematical Theory of Saving" *Economic Journal,* 38, 543-559.

Ruggles, Steven , Matthew Sobek, Trent Alexander, Catherine A. Fitch, Ronald Goeken, Patricia Kelly Hall, Miriam King, and Chad Ronnander (2005). *Integrated Public Use Microdata Series*: Version 3.0 [Machine-readable database]. Minneapolis, MN: Minnesota Population Center [producer and distributor], 2004. http://www.ipums.org.

Solow, Robert (1956). “A Contribution to the Theory of Economic Growth,” *Quarterly Journal of Economics,* 70, pp. 65-94.

Welch, Finis (1979) "Effects of Cohort Size on Earnings: The baby Boom Babies’ Financial Boost" *Journal of Political Economy*, 87, 65-97.

Welch, Finis (1990) "In defense of Inequality" *American Economic Review,* 89, 1-17.

A Appendix: Partial Effects of Supply on Wages

The total effect of immigrants on the wages of natives in group k, j, as calculated in (8), is the combination of three types of effects. The first is the impact of foreign workers in the same education and experience group k, j on the wages of natives in the same group. This effect is obtained by differentiating (6) with respect to $\ln(F_{kj})$ and expressing the results in terms of the percentage changes in the wage of group k, j ($\Delta \ln w_{Hkj} = \Delta w_{Hkj}/w_{Hkj}$) that results from a percentage change of the share of foreign-born in the total employment of the same group ($\Delta F_{kj}/L_{kj} = \Delta F_{kj}/F_{kj} * F_{kj}/L_{kj} = \Delta \ln(F_{kj}) * F_{kj}/L_{kj}$):

$$\frac{\Delta w_{Hkjt}/w_{Hkjt}}{\Delta F_{kjt}/L_{kjt}} = \left[\frac{1}{\delta} + \left(\frac{1}{\theta} - \frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right) + \left(\frac{1}{\sigma_k} - \frac{1}{\theta}\right)\left(\frac{1}{s_{kjt}}\right)\right] \frac{s_{Fkjt}}{\varkappa_{Fkjt}} \varkappa_{kjt} \tag{17}$$

The second type of effects is given by the impact of foreign-born workers in a different experience group $i \neq j$ and the same education group k. Differentiating (6) with respect to $\ln(F_{ki})$ we obtain:

$$\frac{\Delta w_{Hkjt}/w_{Hkjt}}{\Delta F_{kit}/L_{kit}} = \left[\frac{1}{\delta} + \left(\frac{1}{\theta} - \frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right)\right] \frac{s_{Fkjt}}{\varkappa_{Fkjt}} \varkappa_{kjt} \tag{18}$$

The third and last type of effects is given by the impact of foreign-born workers in a different education group $m \neq k$, whatever their experience group: Differentiating (6) with respect to $\ln(F_{mit})$ we obtain:

$$\frac{\Delta w_{Hkjt}/w_{Hkjt}}{\Delta F_{mit}/L_{mit}} = \frac{1}{\delta} \frac{s_{Fkjt}}{\varkappa_{Fkjt}} \varkappa_{kjt} \tag{19}$$

One can then easily combine the above effects to obtain the expression (8) reported in the text.

B Appendix: Elasticities assuming fixed physical capital

If we assume constant physical capital in response to immigration ($K = \overline{K}$), the expression of the wage of the domestic workers of experience j and education k is the following:

$$\ln(w_H)_{kjt} = \ln\left(\widetilde{A}\overline{K}^{\alpha}\right) + \left(\frac{1}{\delta} - (1-\alpha)\right)\ln(\widetilde{C_t}) + \ln\Phi_{kt} - \left(\frac{1}{\delta} - \frac{1}{\theta}\right)\ln(C_{kt}) + \ln\Phi_{kjt} - \left(\frac{1}{\theta} - \frac{1}{\sigma k}\right)\ln(C_{kjt}) + \ln\Phi_{kjHt} - \frac{1}{\sigma k}\ln(H_{kt}) \tag{20}$$

Hence the partial effect of a change in the supply of foreign-born workers in the experience-education cell k, j on wages of natives in the same group, keeping $\widetilde{C_t}$ and C_{kt} fixed, is:

$$\varepsilon_{kjt}^{partial} = \frac{\Delta w_{Hkjt}/w_{Hkjt}}{\Delta F_{kjt}/L_{kjt}} = \left[\left(\frac{1}{\delta} - (1-\alpha)\right) + \left(\frac{1}{\theta} - \frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right) + \left(\frac{1}{\sigma_k} - \frac{1}{\theta}\right)\left(\frac{1}{s_{kjt}}\right)\right] \frac{s_{Fkjt}}{\varkappa_{Fkjt}} \varkappa_{kjt} \tag{21}$$

while the total effect of immigration on wages of domestic workers in cell j, k is:

$$\varepsilon_{kjt}^{total} = \frac{\Delta w_{Hkjt}/w_{Hkjt}}{\Delta F_t/L_t} = \frac{\left(\frac{1}{\sigma_k} - \frac{1}{\theta}\right)\left(\frac{1}{s_{kjt}}\right)\left(\frac{s_{Fkjt}}{\varkappa_{Fkjt}}\right)\frac{\Delta F_{kjt}}{L_t} + \left(\frac{1}{\theta} - \frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right)\sum_i \frac{s_{Fkit}}{\varkappa_{Fkit}}\frac{\Delta F_{kit}}{L_t} + \left(\frac{1}{\delta} - (1-\alpha)\right)\sum_m \sum_i \frac{s_{Fmit}}{\varkappa_{Fkmt}}\frac{\Delta F_{mit}}{L_t}}{\Delta F_t/L_t} \tag{22}$$

Tables and Figures

Table 1

Year	Percentage of Foreign-Born in U.S. Employment	Source
1970	2.6%	Census (IPUMS)
1980	4.5%	Census (IPUMS)
1990	7.5%	Census (IPUMS)
2000	11.6%	Census (IPUMS)
2003	13.2%	CPS (IPUMS)

Notes: Employment is defined as people working at least one hour in the previous week and one week in the previous year between 17 and 65 years of age.
Census(IPUMS)= Integrated Public Use Microdata from the US Census, Ruggles et al (2005)
CPS (IPUMS)= March Rotation of the Current Population Survey, integrated with Census data, Ruggles et al. (2005).

Table 2

Year	Average Yearly Change in Foreign-Born as Percentage of Initial Employment	Change in Percentage Points of the Real Interest Rate During the Decade
1960's	-0.29%	-1.96
1970's	0.25%	-2.2
1980's	0.30%	+5.86
1990's	0.51%	+0.62

Notes: The data on the real interest rate are calculated as the nominal rates on 6-month treasury bonds, net of realized inflation.

Table 3
Index of Congruence in the choice of Occupations, by schooling and experience, Census 2000

3A: High School Dropouts

Index of Congruence	Foreign, Same experience	Natives 0-10	Natives 10-20	Natives 20-30	Natives 30-40
Natives, 0-10	0.52	1			
Natives, 10-20	0.72	0.47	1		
Natives, 20-30	0.70	0.40	0.93	1	
Natives, 30-40	0.74	0.35	0.83	0.92	1
Average	**0.67**	**0.66**			

3B: High School Graduates

Index of Congruence	Foreign, Same experience	Natives 0-10	Natives 10-20	Natives 20-30	Natives 30-40
Natives, 0-10	0.73	1			
Natives,10-20	0.64	0.76	1		
Natives,20-30	0.52	0.37	0.92	1	
Natives,30-40	0.50	0.40	0.77	0.90	1
Average	**0.60**	**0.68**			

3C: College Dropouts

Index of Congruence	Foreign, Same experience	Natives 0-10	Natives 10-20	Natives 20-30	Natives 30-40
Natives, 0-10	0.72	1			
Natives,10-20	0.60	0.60	1		
Natives,20-30	0.50	0.35	0.69	1	
Natives,30-40	0.60	0.23	0.86	0.87	1
Average	**0.60**	**0.60**			

3D: College Graduates

Index of Congruence	Foreign, Same experience	Natives 0-10	Natives 10-20	Natives 20-30	Natives 30-40
Natives, 0-10	0.55	1			
Natives,10-20	0.65	0.89	1		
Natives,20-30	0.55	0.80	0.90	1	
Natives,30-40	0.57	0.70	0.82	0.94	1
Average	**0.58**	**0.85**			

Table 4
Relative U.S.-Foreign-Born Wage Elasticity in the Same Education-Experience Cell

	Male, Weekly Wages			All Workers		Yearly Wages		Unweighted	
Specification	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Method of Estimation	**OLS**	**IV (all)**	**IV (new)**	**IV (all)**	**IV (new)**	**IV (all)**	**IV (new)**	**IV (all)**	**IV (new)**
Constrained $1/\bar{\sigma}$ across schooling groups									
$1/\bar{\sigma}$	0.18** (0.04)	0.25** (0.07)	0.28** (0.09)	0.22** (0.06)	0.23** (0.06)	0.45** (0.10)	0.42** (0.13)	0.18** (0.08)	0.24** (0.11)
Unconstrained $1/\sigma_k$ Across Schooling Groups									
$1/\sigma_{HSD}$	0.18** (0.04)	0.20** (0.08)	0.28* (0.15)	0.20** (0.08)	0.16 (0.11)	0.37** (0.11)	0.11 (0.20)	0.10 (0.07)	0.20* (0.11)
$1/\sigma_{HSG}$	0.12** (0.05)	0.12 (0.08)	0.13 (0.16)	0.15 (0.08)	0.06 (0.11)	0.27** (0.12)	0.06 (0.24)	0.03 (0.07)	0.06 (0.15)
$1/\sigma_{COD}$	0.13** (0.05)	0.12 (0.07)	0.18 (0.20)	0.11 (0.07)	0.06 (0.05)	0.30** (0.10)	0.01 (0.33)	0.01 (0.07)	0.11 (0.16)
$1/\sigma_{COG}$	0.20** (0.03)	0.20** (0.06)	0.32** (0.16)	0.23** (0.06)	0.19* (0.10)	0.40** (0.08)	0.41 (0.30)	0.13* (0.06)	0.24** (0.12)
First Stage Regressions, Constrained estimation									
$\ln(1/F_{kjn})$	n.a.	0.35** (0.10)	0.32** (0.10)	0.37** (0.10)	0.37* (0.10)	0.35** (0.10)	0.32** (0.10)	0.27* (0.07)	0.27* (0.09)
F-test of Exclusion	n.a.	11.2 (p=0.001)	9.6 (p=0.003)	13 (p=0.001)	13 (p=0.001)	11.2 (p=0.001)	9.6 (p=0.003)	12.1 (0.001)	9.9 (0.002)
Observations	160	160	128	160	128	160	128	160	128

Notes: Period 1960-2000, decennial censuses. New immigrants only available for the period 1970-2000.
Dependent variable: $\ln(w_{Hkjt}/w_{Fkjt})$, explanatory variable $\ln(H_{kjt}/F_{kjt})$. All regressions include education by year and experience by year fixed effects.
IV(all) estimation using $\ln(1/F_{kj})$ as instrument for $\ln(H_{kj}/F_{kj})$, where F_{kj} is the number of foreign-born employed in educational group k and experience group j, and H_{kj} is the number of U.S.-born employed in educational group k and experience group j.
IV(new) estimation using $\ln(1/ F^{new}_{kj})$ as instrument for $\ln(H_{kj}/ F^{new}_{kj})$, where F^{new}_{kj} is the number of foreign-born employed in educational group k and experience group j, and immigrated to the U.S. during the previous 10 years.
Weight: Cell size in employment terms.
Heteroskedasticity-robust standard errors, clustered by education-experience cells.

Table 5
Relative U.S.-Foreign-Born Wage elasticity in the Same Education-Experience Cell, Young Workers Only (Experience Less Than 20 Years)

	Male, Weekly Wages			All Workers		Yearly Wages		Unweighted	
Specification	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Method of Estimation	**OLS**	**IV (all)**	**IV (new)**	**IV (all)**	**IV (new)**	**IV (all)**	**IV (new)**	**IV (all)**	**IV (new)**
Constrained $1/\overline{\sigma}$ Across Schooling Groups									
$1/\overline{\sigma_k}$	0.27** (0.03)	0.30** (0.05)	0.22** (0.06)	0.28** (0.04)	0.21** (0.06)	0.39** (0.07)	0.26** (0.09)	0.29** (0.04)	0.25** (0.05)
Unconstrained $1/\sigma_k$ Across Schooling Groups									
$1/\sigma_{HSD}$	0.30** (0.04)	0.24** (0.08)	0.33** (0.05)	0.25** (0.08)	0.33** (0.04)	0.43** (0.08)	0.50** (0.22)	0.25** (0.08)	0.33** (0.04)
$1/\sigma_{HSG}$	0.05 (0.06)	0.07 (0.05)	0.18 (0.20)	0.05 (0.10)	0.06 (0.10)	0.05 (0.05)	0.07 (0.32)	0.06** (0.03)	0.12 (0.20)
$1/\sigma_{COD}$	0.03 (0.06)	0.07 (0.06)	0.10 (0.10)	0.04 (0.10)	-0.08 (0.20)	0.21* (0.12)	0.13 (0.22)	0.14** (0.07)	0.32 (0.17)
$1/\sigma_{COG}$	0.25** (0.07)	0.32** (0.12)	0.28** (0.10)	0.21** (0.08)	0.20** (.08)	0.21* (0.11)	0.20** (0.10)	0.38** (0.13)	0.29** (0.08)
First Stage Regressions, Constrained Estimation									
$\ln(1/F_{kjn})$	n.a.	0.98** (0.19)	0.82** (0.17)	1.29** (0.28)	1.01** (0.24)	0.98** (0.19)	0.82** (0.17)	0.93** (0.16)	0.89** (0.17)
F-test of Exclusion	n.a.	25.3 (p=0.000)	23.1 (p=0.000)	20.3 (p=0.000)	17.5 (p=0.000)	25.3 (p=0.000)	23.1 (p=0.000)	33.4 (p=0.000)	28.0 (p=0.000)
Observations	80	80	64	80	64	80	64	80	64

Notes: period 1960-2000, decennial censuses. New immigrants only available for the period 1970-2000.
Dependent variable: $\ln(w_{Hkjt}/w_{Fkjt})$, explanatory variable $\ln(H_{kjt}/F_{kjt})$. All regressions include education by year and experience by year fixed effects.
IV(all) estimation using $\ln(1/F_{kj})$ as instrument for $\ln(H_{kj}/F_{kj})$, where F_{kj} is the number of foreign-born employed in educational group k and experience group j, and H_{kj} is the number of U.S.-born employed in educational group k and experience group j.
IV(new) estimation using $\ln(1/ F^{new}_{kj})$ as instrument for $\ln(H_{kj}/F_{kj})$, where F^{new}_{kj} is the number of foreign-born employed in educational group k and experience group j, and immigrated to the U.S. during the previous 10 years .
Weight: Cell size in employment terms. Heteroskedasticity-robust standard errors, clustered by education-experience cells.

Table 6
Estimates of $1/\theta$ Relative Wage Elasticity Across Experience Cells

	CES Foreign-U.S.-born ($\sigma_k = \overline{\sigma} = 3$),		CES Foreign- U.S.-born ($\sigma_k = \overline{\sigma} = 4$)		CES Foreign- U.S.-born ($\sigma_k = \overline{\sigma} = 5$)		Simple Sum Foreign-U.S.-born ($\sigma_k = \overline{\sigma} = \infty$)	
Specification	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Sample:	**Males**	**All Workers**	**Males**	**All Workers**	**Males**	**All Workers**	**Males**	**All Workers**
Weekly Wages	0.29** (0.08)	0.20** (0.05)	0.30** (0.07)	0.21** (0.05)	0.28** (0.07)	0.25** (0.05)	0.25** (0.06)	0.20** (0.04)
Yearly Wages	0.27** (0.09)	0.20** (0.07)	0.27** (0.09)	0.21** (0.06)	0.24** (0.09)	0.21** (0.06)	0.23** (0.06)	0.20** (0.03)
Hourly Wages	0.34** (0.06)	0.22** (0.04)	0.34** (0.06)	0.23** (0.04)	0.34** (0.06)	0.23** (0.04)	0.31** (0.08)	0.23** (0.03)
Not weighted	0.30** (0.07)	0.22** (0.05)	0.30** (0.07)	0.22** (0.05)	0.30** (0.06)	0.22** (0.05)	0.24** (0.06)	0.20** (0.04)
Observations	128	128	128	128	128	128	128	128

Notes: Estimates obtained from equation (13) in the text. Dependent variable $\ln(W_{kjt})$, natural logarithm of the total wage of workers (U.S.- and foreign-born) in the k, j group. Explanatory variable $\ln(C_{kjt})$, constructed as described in the text. Method of estimation: instrumental variable with $\ln(F^{new}_{kjt})$ as instrument for $\ln(C_{kjt})$. All regressions include education by experience and education by year fixed effects.
Weight: Cell size in employment terms, except penultimate row (unweighted).
Heteroskedasticity-robust standard errors, clustered by education-experience cells.

Table 7
Estimates of $1/\delta$ Relative Wage Elasticity Across Education Cells

$1/\delta$	**CES Foreign- U.S.-born ($\sigma_k = \bar{\sigma} = 5$)**		**CES Foreign- U.S.-born ($\sigma_k = \bar{\sigma} = 3$)**	
Specification	**1**	**2**	**3**	**4**
Sample:	**Males**	**All Workers**	**Males**	**All Workers**
Instruments: All Foreign-Born				
Simple sum of experience groups, $\theta = \infty$	0.42** (0.14)	0.55** (0.16)	0.40** (0.16)	0.54** (0.17)
CES experience groups $\theta = 4$	0.31** (0.12)	0.46** (0.15)	0.33** (0.12)	0.46** (0.15)
CES experience groups $\theta = 3$	0.41** (0.15)	0.45** (0.14)	0.41** (0.14)	0.46** (0.14)
Instruments: Recently Immigrated				
Simple sum of experience groups, $\theta = \infty$	0.43** (0.15)	0.57** (0.17)	0.41** (0.14)	0.56** (0.17)
CES experience groups $\theta = 4$	0.32** (0.13)	0.45** (0.15)	0.34** (0.12)	0.45** (0.15)
CES experience groups $\theta = 3$	0.37** (0.14)	0.42** (0.15)	0.40** (0.14)	0.47** (0.14)

Notes: Estimates obtained from equation (15) in the text. Dependent variable $\ln(W_{kt})$, natural logarithm of the total wage of workers (U.S.- and foreign-born) in the k educational group. Explanatory variable $\ln(C_{kt})$, constructed as described in the text. Total number of observations: 16.
Method of estimation: instrumental variable, using $\ln(F_{kt})$ as instruments for $\ln(C_{kt})$ in rows 1-3 and $\ln(F^{new}_{kt})$ as instruments for $\ln(C_{kt})$ in rows 4-6. All regressions include time fixed effects and education-specific time trends.
Weight: Cell size in employment terms.
Heteroskedasticity-robust standard errors.

Table 8
Calculated Effects on Wages of Domestic Workers of Immigrants Inflows, 1990-2000

Assumptions:	Endogenous Capital, Estimated Elasticity Between U.S.-Foreign-Born, σ Constrained to be Equal Across Education Groups			Endogenous Capital, Estimated Elasticity Between U.S.-Foreign-Born, σ_k Allowed to Vary Across Education Groups			Endogenous Capital; Perfect Substitutability U.S.- Foreign-Born	Fixed Capital; Perfect Substitutability U.S.- Foreign-Born
Specification	1	2	3	4	5	6	7	8
Estimates of σ_k	Median σ=4	High σ=5.2	Low σ=3.2	Median σ_{HSD}=3.6 σ_{HSG}=17 σ_{COD}=10 σ_{COG}=3.9	High σ_{HSD}=4.6 $\sigma_{HSG}=\infty$ σ_{COD}=28 σ_{COG}=5.5	Low σ_{HSD}=2.9 σ_{HSG}=8.3 σ_{COD}=5.8 σ_{COG}=3.2	σ , imposed = ∞	σ , imposed = ∞
% change, Wage of HS dropouts	-1.7%	-2.4%	-0.4%	-1.2%	-2.2%	-0.2%	-5.5%	-7.0%
% change, Wage of HS graduates	1.4%	1.2%	1.6%	0.8%	0.7%	1.0%	0.6%	-0.7%
% change, Wage of CO dropouts	1.6%	1.5%	1.7%	1.3%	1.1%	1.4%	1.1%	-0.3%
% change, Wage of CO graduates	1.5%	1.3%	1.8%	1.5%	1.2%	1.7%	0.5%	-0.1%
% Change, Average Wage	**1.2%**	**1.0%**	**1.6%**	**1.1%**	**0.9%**	**1.3%**	**0.1%**	**-1.3%**

Notes: Total inflow of foreign born in the decade 1990-2000 is equal to 5.2% of 1990 employment. This is obtained considering employed between 17 and 65 years of age with less than 40 years of potential experience.
The distribution of immigrants across educational groups is $\Delta F_{HSD}/L$=2.3%, $\Delta F_{HSG}/L$=1.0%, $\Delta F_{COD}/L$=0.7%, $\Delta F_{COG}/L$=1.2%.
The values of the elasticities δ and θ are equal to their "focal" estimated values: δ=2, θ=4.

Table 9
Robustness Checks of the Effects on Wages of Domestic Workers of Immigrants Inflows, 1990-2000

Specification	1	2	3	4	5	6	7	8	9
Values of δ, θ	δ=2, θ=3			δ=1.5, θ=3			δ=1.5, θ=4		
Values of σ_k	σ=4	σ_{HSD}=3.6 σ_{HSG}=17 σ_{COD}=10 σ_{COG}=3.9	$\sigma=\infty$	σ=4	σ_{HSD}=3.6 σ_{HSG}=17 σ_{COD}=10 σ_{COG}=3.9	$\sigma=\infty$	σ=4	σ_{HSD}=3.6 σ_{HSG}=17 σ_{COD}=10 σ_{COG}=3.9	$\sigma=\infty$
% change, Wage of HS dropouts	-1.7%	-1.3%	-5.6%	-3.5%	-3.1%	-7.4%	-3.5%	-3.0%	-7.3%
% change, Wage of HS graduates	1.4%	0.8%	0.7%	1.6%	1.0%	0.8%	1.5%	1.0%	0.8%
% change, Wage of CO dropouts	1.6%	1.3%	1.1%	1.9%	1.6%	1.4%	1.9%	1.6%	1.4%
% change, Wage of CO graduates	1.5%	1.6%	0.5%	1.7%	1.7%	0.7%	1.6%	1.6%	0.6%
% Change, Average Wage	**1.2%**	**1.15%**	**0.1%**	**1.3%**	**1.2%**	**0.2%**	**1.3%**	**1.2%**	**0.2%**

Notes: Total inflow of foreign born is equal to 5.2% of 1990 employment. This is obtained considering employed between 17 and 65 years of age with less than 40 years of potential experience.
The distribution of immigrants across educational groups is $\Delta F_{HSD}/L$=2.3%, $\Delta F_{HSG}/L$=1.0%, $\Delta F_{COD}/L$=0.7%, $\Delta F_{COG}/L$=1.2%.

Table 10
Effects on wages of Domestic Workers of Immigrants:
Inflows Relative to the 1970-2000 Period

Period	1970-1980		1980-1990		1980-2000	
Specification	1	2	3	4	5	6
Estimates of σ_k	σ=4	σ_{HSD}=3.6 σ_{HSG}=17 σ_{COD}=10 σ_{COG}=3.9	σ=4	σ_{HSD}=3.6 σ_{HSG}=17 σ_{COD}=10 σ_{COG}=3.9	σ=4	σ_{HSD}=3.6 σ_{HSG}=17 σ_{COD}=10 σ_{COG}=3.9
% change, Wage of HS Dropouts	0.6%	0.6%	0.0%	0.2%	-0.4%	0.2%
% change, Wage of HS Graduates	0.8%	0.5%	1.1%	0.9%	3.2%	2.5%
% change, Wage of CO Dropouts	0.4%	0.1%	0.5%	0.0%	2.3%	1.2%
% change, Wage of CO Graduates	0.5%	0.5%	0.7%	0.7%	2.3%	2.4%
% change, Average Wage	**0.6%**	**0.5%**	**0.7%**	**0.6%**	**2.2%**	**2.0%**

Note: Total inflow of foreign born as follows:
1970-1980 equal to 2.5% of 1970 employment, distributed as follows:
$\Delta F_{HSD}/L$=0.9%,$\Delta F_{HSG}/L$=0.6%, $\Delta F_{COD}/L$=0.5%, $\Delta F_{COG}/L$=0.5%..
1980-1990 equal to 3.0% of 1980 employment, distributed as follows:
$\Delta F_{HSD}/L$ =1.2%, $\Delta F_{HSG}/L$ =0.4%, $\Delta F_{COD}/L$ =0.7%, $\Delta F_{COG}/L$ =0.7%.
1980-2000 equal to 9.1% of 1980 employment, distributed as follows:
$\Delta F_{HSD}/L$ =4.0%, $\Delta F_{HSG}/L$ =1.6%, $\Delta F_{COD}/L$ =1.5%, $\Delta F_{COG}/L$ =2.0%.
1970-2000 equal to 15% of 1970 employment, distributed as follows:
$\Delta F_{HSD}/L$ =6.3%, $\Delta F_{HSG}/L$ =2.8%, $\Delta F_{COD}/L$ =2.5%, $\Delta F_{COG}/L$ =3.3%.
The values of the other elasticities are equal to the median estimated values: δ=2, θ=4.

Figure 1

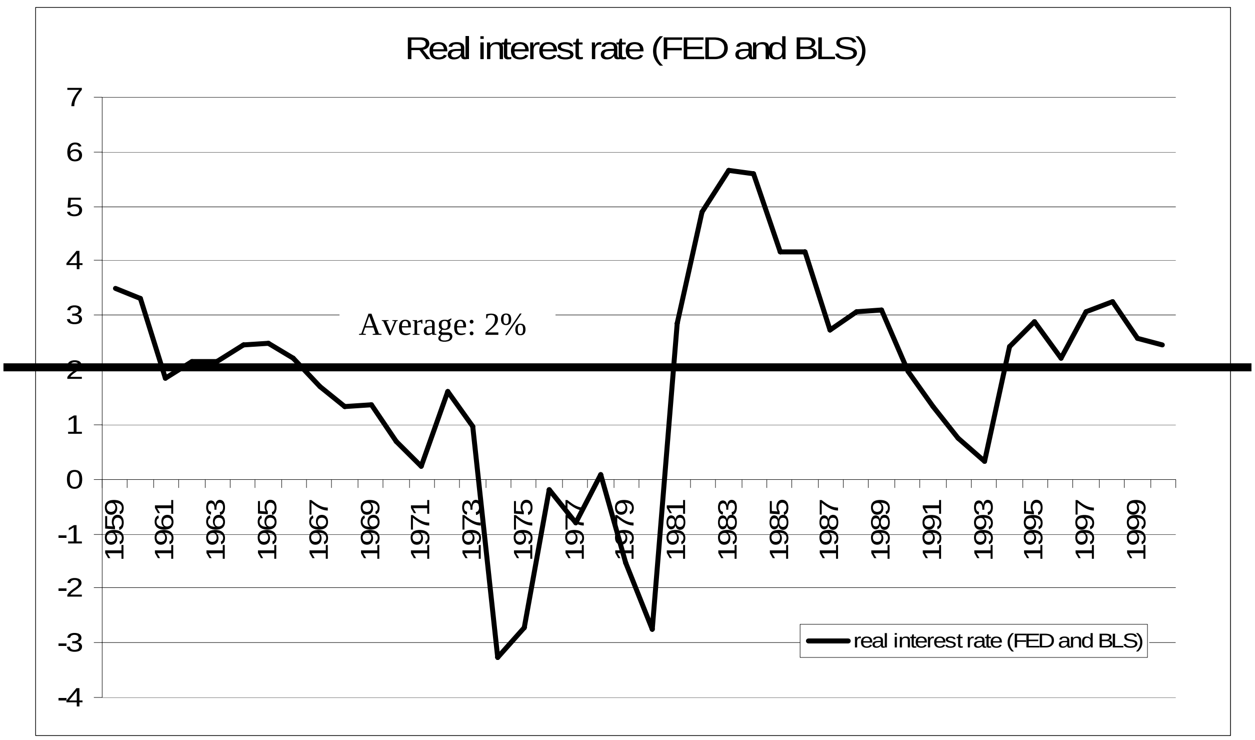

Real interest rate (FED and BLS)
7
6
5
4
3
2
1
0
-1
-2
-3
-4
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
Average: 2%
real interest rate (FED and BLS)

Figure 2

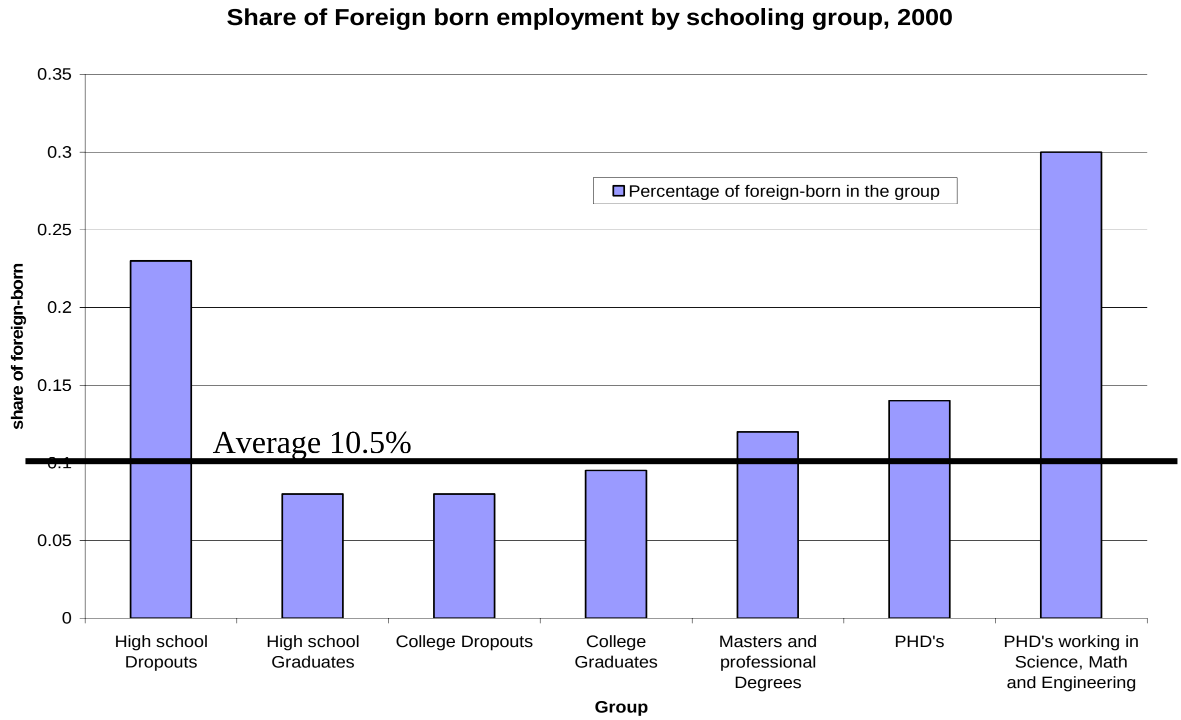


Figure 3

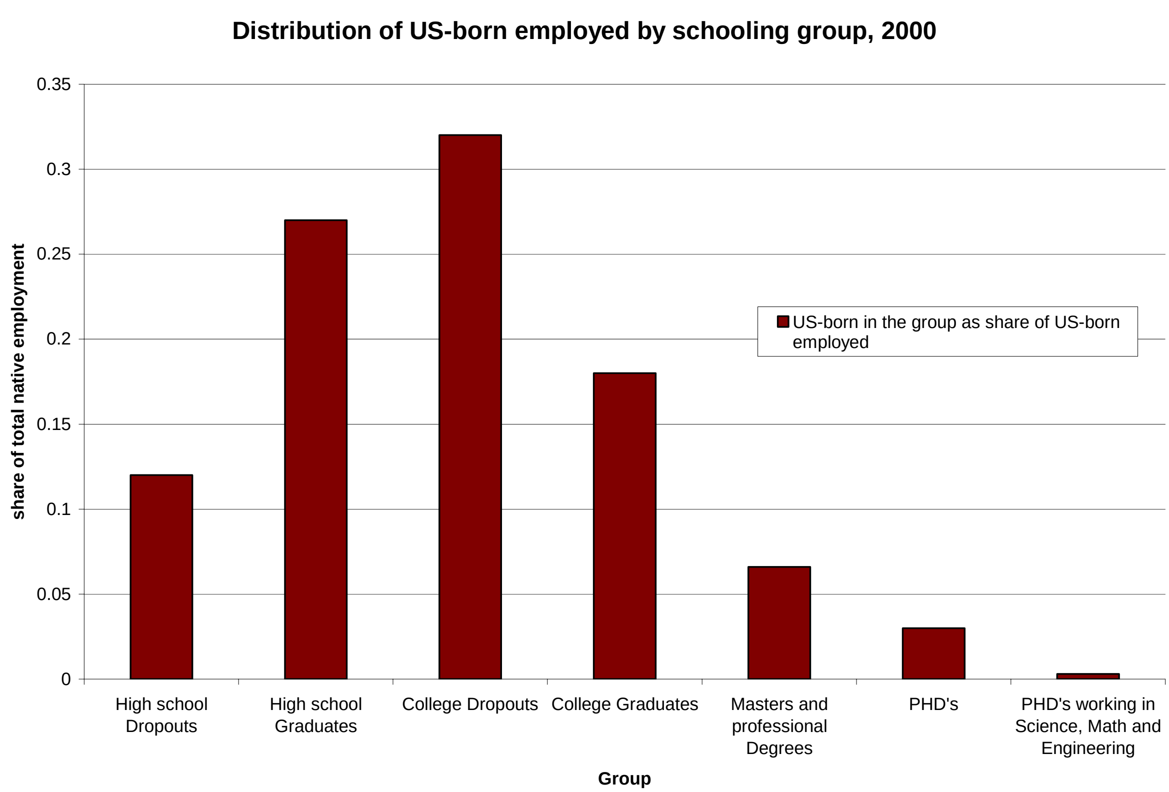
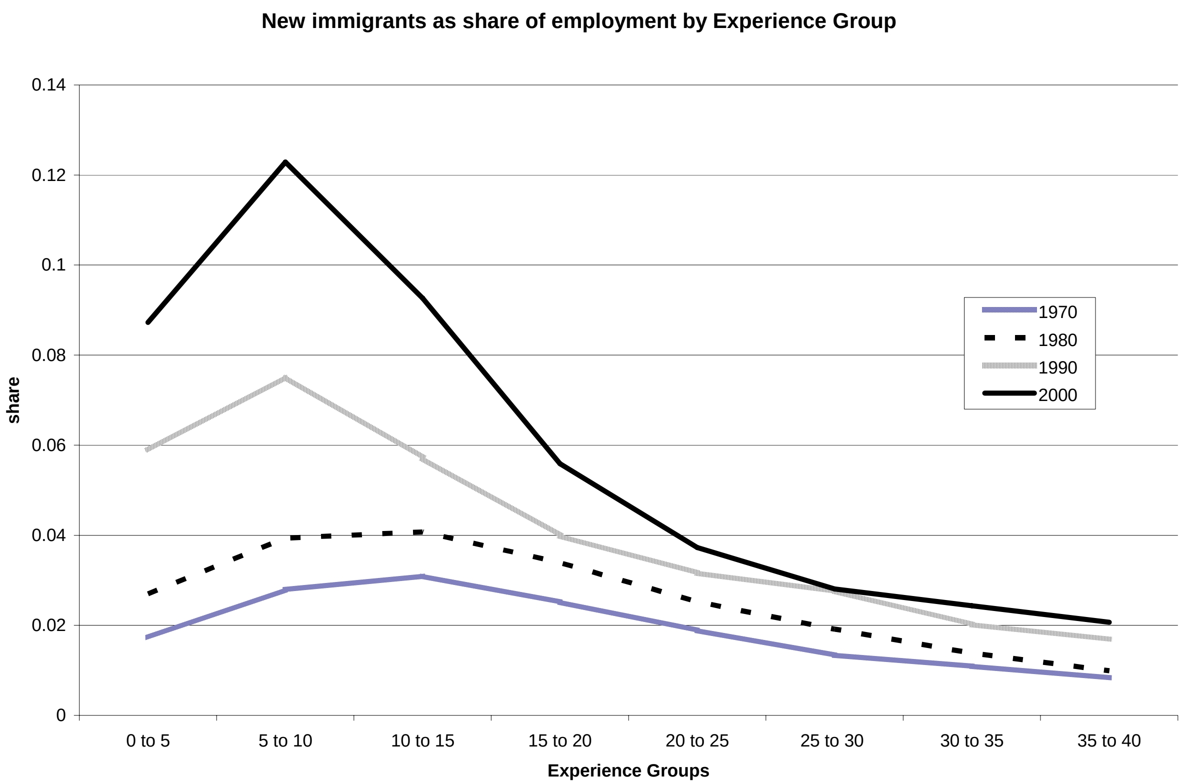


Figure 4


New immigrants as share of employment by Experience Group
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
share
1970
1980
1990
2000
0 to 5
5 to 10
10 to 15
15 to 20
20 to 25
25 to 30
30 to 35
35 to 40
Experience Groups