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Rethinking the Effects of Immigration on Wages

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July, 2006

Abstract

This paper revisits the following important question: what is the effect of immigration on average and individual wages of U.S.-born workers? In particular we analyze the impact of surging immigration, on average real wages and on the increased wage dispersion during the period 1990-2004. Building on Borjas (2003) we emphasize the need for a general equilibrium approach to analyze this problem. The impact of immigrants on wages of US born workers can be evaluated only by accounting carefully for labor market and capital market interactions in production. This requires to assume a production function, a mechanisms of physical capital accumulation and to derive labor demands for different types of workers (by education and experience). The usual "reduced form" approach estimates the effect of immigrants on wages of US-born workers within the same skill group. Such method only provides estimates of a partial effect, usually negative and uninformative of the total effect of immigration on wages. Using our general equilibrium approach we estimate that physical capital adjsust promptly and fully to immigration (already within one year) and that immigrants are imperfect substitutes for US-born workers within the same education and experience group (because they choose different occupations and have different skills).These two facts, overlooked by the previous literature, imply a positive and significant effect of immigration on the average wage of U.S.-born workers, already in the short run. They also imply a small negative effect of immigration on wages of uneducated US born workers and a positive wage effect on all other US-born workers. Hence only a very small fraction of the increase in College/High School Dropout wage gap during the 1990-2004 period can be attributed to immigration.

Key Words: Immigration, Skill Complementarities, Average Wage, Wage Dispersion, Physical Capital Adjustment.

JEL Codes: F22, J61, J31.

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1 Introduction

During the last three and a half decades the United States have experienced a remarkable surge in immigration. The share of foreign-born workers in the labor force has steadily grown from 5.3% in 1970 to 14.7% in 2005[1], progressively accelerating, particularly in the period between 1990 and 2005, during which almost one million of immigrants entered the country every year.[2] Parallel to this surge, the debate about the economic effects of immigrants on US natives, and particularly on their wages, has gained momentum both inside academia and in the policy and media arena. Such debate has been particularly lively in the wake of a bill recently passed by the U.S. House of representatives calling, among other provisions, for criminalization of illegal aliens, followed by a second one, passed by the U.S. Senate, calling for a road to legalization of the same group[3]. From the academic perspective two facts have contributed to feed the debate. First, the recent empirical literature about the effect of immigrants on the wages of natives has provided a mixed set of results. Second, the group of uneducated workers (without a high school degree) has become increasingly large among recent immigrants, while at the same time the real wage of uneducated U.S.-born workers has performed very poorly: it even declined in real terms during the recent decades (see, for example, Autor, Katz and Kearny, 2005). It is certainly tempting to attribute the poor wage performance of uneducated U.S. workers to the competition of immigrants, as such connection would provide an easy solution to the problem of wage decline: halt immigration.

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 US workers. Even with more accurate and sophisticated estimates at hand, a consensus has yet to be reached: some economists identified only small effects of immigration on wages (Card, 2001) while others found large negative effects (Borjas, Friedman and Katz, 1997).[4] Recently, however, the latter view of a large negative impact of immigration on wages, particularly of uneducated workers, seems to have gained momentum. An influential article by George Borjas, (2003), followed by Borjas and Katz (2005) and Borjas (2006) that use a similar method, argue, using national data from five decennial US censuses (1960-2000) and a convincing empirical approach, that U.S. workers lost, on average, about 3% of the real value of their wages due to immigration over the period 1980-2000 and such loss reached almost 9% for native workers without a high school degree (Borjas, 2003, Table IX, page 1369).

[1]Author's calculations using 1 percent Integrated Public Use Microdata Series (IPUMS) for year 1970 and Current Population Survey March Supplement, Ruggles et al (2006), for year 2005.

[2]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.

[3]The bills were, respectively, the Border Protection, Anti-Terrorism, and Illegal Immigration Control Act (H.R. 4437) passed in December 2005 by the U.S. House of Representatives and the Comprehensive Immigration Reform Act (S.2611) passed in May 2006 by the U.S. Senate.

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

Our paper builds on section VII of the article by George Borjas (2003) but takes a fresh look at some critical issues that results in substantial revisions of several results. Our key idea is that the effects of immigration on wages can only be measured within a *general equilibrium* framework. More specifically, a study on the effects of immigration on wages of different types of workers (by education, experience and nativity) should begin with, and build on, a production function that describes how these different types of workers interact with each other (complement and substitute each other) and with physical capital to produce output. Then, one can derive the demand for each type of labor, which depends on productivity and employment of the other labor types as well as on physical capital. Finally one can use market clearing conditions to obtain wage equations, from the labor demands and supplies, and estimate the elasticities of substitution (wage elasticities) empirically. Those estimates can then be used, going back to the production function, to assess the effect of immigration (a change in supply of different types of workers) on wages (the marginal productivity of different types of workers). Most existing empirical studies directly estimate, instead, a reduced-form wage equation for native workers with certain characteristics (educational or occupational groups) obtaining the elasticity of wages to new immigrants in the same group. Such an approach only provides the "partial" effect of immigration on wages (as it omits all cross-interactions with other workers and with capital) and is uninformative on the overall effect.

Our *general equilibrium* approach has two novel implications. The first is a more careful consideration of the response of physical capital to immigration in the short run. As physical capital complements labor it is important to account for its adjustment. Physical capital accumulates endogenously in order to maintain a constant rate of return in the long run. This assumption is easily derived from any standard long-run open or closed economy model in balanced growth path. It is also supported by the evidence showing that the real return to capital and the capital-output ratio were rather stable, in the US, over the period 1960-2004. Hence, it will be maintained in our analysis of the long-run (10 years) effects of immigration. Moreover in evaluating the "short-run" response of wages to immigration it seems very artificial to maintain a fixed stock of capital, while still accounting for a change in foreign-born workers that occurs over ten (or twenty) years as currently done in the literature. Immigration happens gradually over time and not at the beginning of the decade, it is largely predictable and entrepreneurs are forward looking so that they may invest in anticipation of new workers. Therefore we estimate *empirically*, using yearly data on capital stock and immigration 1960-2004, the adjustment of capital to immigration within each year and we use the *actual* adjustment within a year (rather than the *imposed* zero adjustment) to evaluate the short-run impact of immigration on wages. Interestingly, the empirical evidence strongly supports the idea that physical capital adjusts fully to immigration already within a single year. Hence, in our calculations, we assume that full capital adjustment already takes place in the short run[5].

Secondly, 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. The usual assumption that foreign- and US-born workers are perfect substitutes, within an education-experience group 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, highly motivated and generally talented group, or because they have some culture-specific skills, or because they differ in their preferences and 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 important and novel result of our approach is that, once we account for labor markets and capital market general equilibrium effects, we deeply revise several commonly estimated effects of immigrants on the wages of US natives. First, the average wage of US-born workers experiences a *significant increase* (rather than a decrease) as a consequence of immigration. This results is the consequence of the imperfect substitutability between U.S. and Foreign born workers so that immigration increases wages of U.S.-born at the expenses of a decrease in wages of other foreign-born workers (previous immigrants). Second, the group of least educated U.S.-born workers *suffers a significantly smaller wage loss than previously calculated.* The fact that uneducated foreign-born do not fully and directly substitute for (compete with) uneducated natives, but partly complement their skills, is the reason for this attenuation. Thirdly, *all the other groups of US-born workers* (with at least an high school degree) who accounted for 90% of the U.S.-born labor force in 2004, *gain from immigration.* Finally,

[5] In fact most of the estimates imply that immigration *increases* the capital-output ratio within a year, suggesting the possibility of over-adjustment of capital in the short-run. The positive estimates, however, are never significantly different from 0, hence all estimates are consistent with exactly full adjustment .

even considering only the *"relative" effect* of immigration on real wages of natives, namely its contribution to the widening of the College-High School Dropouts gap and of the College-High School gap, we find only a small contribution of immigration to the first and an even negative contribution (i.e. reduction of the gap) on the second for the 1990-2004 period. The group whose wage is *most negatively affected by immigration* is, in our analysis, *the group of previous immigrants* who, however, probably have the largest non-economic benefits from the immigration of spouses, relatives or friends making them willing to sustain those losses.

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 wages to the inflow of immigrants. This section also makes explicit the analysis of physical capital adjustment and its implications in the short and long run effects of immigration. Section 5 presents the data and the key estimates of the relevant elasticities. Using those estimates, Section **??** evaluates the effect of immigration on the wages of US natives for the period 1990-2004, compares it to previous findings and uses them to account for the increased wage dispersion during the period 1990-2004. Section 7 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. Some of these studies consider explicitly the contribution of immigration to increased wage dispersion and to the poor performance of real wages of the least educated since 1980. Two questions are analyzed by the existing literature. 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 US-born workers? This question requires that we aggregate the wages of quite heterogeneous 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 US-born residents. Therefore, the argument goes, one can neglect this small macro effect and concentrate solely on the second question dealing with the distributional (relative) effects of immigration. Moreover, as immigrants are normally endowed with little physical capital (since few can transport their private homes or enterprises into the US) most of the literature represents immigration as an increase in labor supply for a given capital stock (Borjas, 1995, 2003), and so readily finds a negative impact of immigration on average wages (at least in the short run) and a positive impact of immigration on the return to capital (due to complementarity between the two factors). Most of the recent debate has focused on the effects of immigration on the *relative* wages of more and less educated US-born workers. Some economists argue for a large relative impact adverse to less educated workers (Borjas, 1994, 1999, 2003, 2006; 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 distributional (relative) 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. Our approach builds on the model employed by section VII of Borjas (2003) and uses national data a 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[6].

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 US-born workers. A number of studies on the relative supply of skills and relative wages of US-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 (US versus elsewhere) to categorize imperfectly substitutable groups. Following Borjas (2003), we choose a constant elasticity of substitution (CES) technology and we partition the two groups of US- 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 U.S. and foreign-born 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 few works we are aware of include Jaeger (1996) which only used 1980-1990 metropolitan data and whose estimates may be susceptible to attenuation bias and endogeneity problems related to the use of local

[6] See Borjas (2006) and Borjas, Freeman and Katz (1997) for a discussion.

data and Cortes (2005) who only considers low-skilled workers and uses metropolitan areas data finding very low elasticity of substitution between US and Foreign-born workers. 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).

As for physical capital, we explicitly consider its contribution to production and treat its accumulation as driven by market forces that equalize its real returns and the capital-output ratio. We revise the usual approach that considers capital fixed in the short run simulations. We can explicitly estimate, using yearly data on capital accumulation and immigration, the response of capital to immigration within a year (short run). We find that capital adjusts fully within a year to immigration in order to maintain constant returns. Even if our estimates are not extremely precise we certainly do not find any evidence that immigration lowers the capital-output (and capital-labor) ratio even within the year. Therefore, using the *actual* one-year capital adjustment for the short-run and the assumption of constant returns to capital for the long-run one obtains basically identical effects of immigration on wages in the short and long run: capital adjusts already in the short-run. This is an important departure from the literature, which has not paid much attention to the actual 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) or at least of a fixed stock in the short-run (Borjas, Freeman and Katz, 1997; Borjas and Katz, 2005).

Some studies on the effects of immigration on wages have specifically focussed on immigration (along with trade) as a candidate to explain the worsening of income distribution in the US during the years following 1980. In particular Borjas, Friedman and Katz (1997) found a relevant contribution of immigration to the widening of the wage gap between high school dropouts and high school graduates during the 1980-1995 period but no contribution to the widening of the College-High School wage gap. In the light of new studies (notably Autor, Katz and Kearny, 2005, 2006) that document the further evolution of College-High School and High School-Dropouts wage gaps during the 1990-2005 period and in the light of our new results that reduce the adverse impact of immigration on wage distribution we re-visit that literature by calculating the contribution of immigration to wage dispersion for the 1990-2004 period.

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 US natives (Card, 2001; Card and Di Nardo, 2000; Lewis, 2003) and correcting for the endogeneity of immigrant location (both factors would cause an attenuation bias in the estimates). These studies find a small negative partial effect of immigrants on wages. On the other hand, our previous work (Ottaviano and Peri, 2005a, 2005b, 2006) has pointed out a positive effect of immigration on the average wage of US natives across US metropolitan areas. This positive and significant effect survived 2SLS estimation, using instruments that should be exogenous to city-specific unobservable productivity shocks.[7] The complementarity in production illustrated at the national level in this paper could also be at work at the city level. Accordingly, the model proposed in this paper can reconcile the negative partial effects with the positive average effect of immigration at the local level.[8]

3 Theoretical Framework

To evaluate the effects of immigrants on the wages of natives and other foreign-born workers when they differ by education, experience and other characteristics, we need a model of how the marginal productivity of a type of workers changes in response to changes in the supply of other types of labor. At the same time it is important to account for the response of physical capital to immigration. 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.

3.1 Production Function

Following Borjas (2003) who builds on 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. US-born and foreign-born workers are allowed a further degree of imperfect substitutability even when they have the same education and experience. While the nested CES function imposes some restrictions on the elasticities of substitution across skill groups it has the advantage of being parsimonious in the parameters, widely used and easily comparable with a large body of articles in the labor and macro literature. The production function we use is given by the following expression:

$$Y_t = A_t L_t^{\alpha} K_t^{1-\alpha} \tag{1}$$

where Y_t is aggregate output , A_t is total factor productivity (TFP), K_t is physical capital, L_t is a CES aggregate of different types of labor (described below), and $\alpha \in (0, 1)$ is the income share of labor. All variables, as indicated by the subscripts, are relative to year t. The production function is a constant returns to scale (CRS) Cobb-Douglas combination of capital K_t and labor L_t. Such a functional form has been widely used in the macro-growth literature (recently, for instance, by Jones, 2005 and Caselli and Coleman, 2006) and is supported by the empirical observation that the share of income going to labor, α, is constant in the long run

[7] 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.

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

and across countries (Kaldor, 1961; Gollin, 2002). The labor aggregate L_t is defined as:

$$L_t = \left[\sum_{k=1}^{4} \theta_{kt} L_{kt}^{\frac{\delta-1}{\delta}} \right]^{\frac{\delta}{\delta-1}} \tag{2}$$

where L_{kt} is an aggregate measure of workers with educational level k in year t; θ_{kt} are education-specific productivity levels (standardized so that $\sum_k \theta_{kt} = 1$ and any common multiplying factor can be absorbed in the TFP term A_t). 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:

$$L_{kt} = \left[\sum_{j=1}^{8} \theta_{kj} L_{kjt}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{3}$$

where j is an index spanning experience intervals of five years between 0 and 40, so that $j = 1$ captures workers with $0-5$ years of experience, $j = 2$ those with $6-10$ years, and so on. The parameter $\eta > 0$ measures the elasticity of substitution between workers in the same education group but with different experience levels and θ_{kj} are experience-education specific productivity level (standardized so that $\sum_j \theta_{kj} = 1$ for each k and assumed invariant over time, as in Borjas, 2003) . 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 $\eta > \delta$. Finally, differently from most of the literature, we define L_{kjt} as a CES aggregate of home-born and foreign-born workers. Denoting by H_{kjt} and F_{kjt} 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:

$$L_{kjt} = \left[\theta_{Hkjt} H_{kjt}^{\frac{\sigma_k-1}{\sigma_k}} + \theta_{Fkjt} F_{kjt}^{\frac{\sigma_k-1}{\sigma_k}} \right]^{\frac{\sigma_k}{\sigma_k-1}} \tag{4}$$

Foreign-born workers 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 US-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 $\sigma_k > \eta$. We analyze this issue in detail in Section 5 below. Ultimately, we allow the empirical analysis to reveal whether US-born workers and foreign-born workers within the same education and experience group are perfect substitutes ($\sigma_k = \infty$) or not.[9] We also allow, as indicated by the subscript k, that the elasticity of substitution between US- and foreign-born workers differ across education groups (more on this below). Finally, the terms θ_{Hkjt} and θ_{Fkjt} measure the specific productivity levels of foreign- and home-born workers and they may vary across groups and years (in the empirical identification we impose a systematic structure on their time variations) . They are also standardized so that $(\theta_{Hkjt} + \theta_{Fkjt}) = 1$.

3.2 Physical Capital Adjustment

Physical capital adjustment to immigration may not be immediate. However, investors and entrepreneurs are motivated by profit, well informed and forward looking. Hence they may respond fairly quickly to inflows of labor and to the consequent increase in the marginal productivity of capital. How fast they respond is an empirical question. Immigration is not an unexpected and instantaneous shock. It seems odd, therefore, to treat the short run effect as the impact of immigration for fixed capital stock: for how long is capital fixed? and why?. Immigration is an ongoing phenomenon, distributed over years, predictable and rather slow. In spite of the acceleration in legal and illegal immigration after 1990 the inflow of immigrants measured less than 0.5% of the labor force each year between 1960 and 2004. It is reasonable, therefore to think of this issue more dynamically with investments continuously responding to these flow. In fact entrepreneurs may even make investments in anticipation of new workers (while waiting for their H1B visa or for their bureaucratic procedures) in which case capital may even "overshoot" immigration in the short run. Our assumption, therefore, is that the mechanisms of capital accumulation are always at work. Such mechanisms may be fast enough that the full adjustment of the capital stock to immigration is achieved within a year. In this case the economy is continuously on a Balanced growth path such as in the Ramsey (1928) or the Solow (1956) models (with constant K/Y ratio and K/L growing at the rate of TFP). Alternatively, the adjustment may be slower and more sluggish (due to adjustment costs) in which case the yearly migratory flows would affect temporarily the ratio K/Y (and K/L). How much and for how long immigration affects K/Y (and K/L) is an empirical question and we address it in section 3.2.2. We find such a feeble and insignificant effect of immigration flows on K/Y (and K/L), even within one year, that it seems eminently plausible to infer that the U.S. economy moves continuously along a BGP in response to migration inflows. Remarkably several estimates of the effect of immigration on K/Y within the year turn out to be *positive*! Even using the (highly non significant) negative estimates of immigration on K/Y within a year, the departure from constant K/Y is rather small and has only a minuscule effect on wages. Hence the assumption of full capital adjustment to immigration seems theoretically sound and empirically appropriate both for the short run (one year) and, "a fortiori", for the long run (a decade). To the contrary, the traditional

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

assumption of the literature for the "short-run", namely that capital is fixed in response to 10 years worth of immigrants (as in Borjas 2003 and Borjas and Katz 2006) produces what we consider an unjustified and unreasonable negative effect of immigration on wages.

3.2.1 Partial Adjustment, Total Adjustment and Wages

Given the production function in (3.1) the effect of physical capital K_t on the wages of individual workers operates through the effect on the marginal productivity of the aggregate L_t. Let us call w_t^L the compensation to the composite factor L_t,which is equal to the aggregate wages. In a competitive market it equals the marginal productivity of L_t, hence:

$$w_t^L = \frac{\partial Y_t}{\partial L_t} = \alpha A_t \left(\frac{K_t}{L_t}\right)^{1-\alpha} \tag{5}$$

Assuming either international capital mobility or capital accumulation, along the balanced growth path of the Ramsey (1928) or Solow (1956) models, the real interest rate r and the aggregate capital-output ratio K/Y are both constant in the long run. This assertion is also supported in the data as the real return to capital and the capital-output ratio in the US do not exhibit any trend in the long run (Kaldor, 1961). In particular, this is true for our period of consideration 1960-2004 as depicted in Figure 1, where the capital-output ratio (K_t/L_t) is measured as the real US GDP divided by the real value of total fixed assets in the U.S. economy (see below for detailed sources and definitions). Figure 1 shows slow cyclical movements of the variable K_t/L_t but remarkable stability in the long-run. In order to show the effect of different patterns of capital adjustment on wages (w_t^L) it is useful to write the capital stock as $K_t = k_t L_t$ where k_t is the capital-labor ratio. Alternatively using (1) one can write the capital stock as a function of the capital-output ratio, $\kappa_t (= K_t/Y_t)$, as: $K_t = A^{\frac{1}{\alpha}} \kappa_t^{\frac{1}{\alpha}} L_t$. Hence w_t^L (from equation 5) can be expressed in either of the following two forms:

$$w_t^L = \alpha A_t \left(k_t\right)^{1-\alpha} = \alpha A_t^{\frac{1}{\alpha}} \kappa_t^{\frac{1-\alpha}{\alpha}} \tag{6}$$

Expressions (6) makes explicit an important property of aggregate wages w_t^L: in balanced growth path equilibrium, because the capital-output ratio κ_t is constant ($\kappa^* = \frac{1-\alpha}{r}$, where r is the real return to capital) and the capital-labor ratio k_t depends only on TFP ($k_t^* = \left(\frac{1-\alpha}{r}\right)^{\frac{1}{\alpha}} A_t^{\frac{1}{\alpha}}$), and the aggregate wage w_t^L does not depend on the total supply of workers L_t. Moreover, at any time, the change in labor supply due to immigration affects aggregate wages only if (and by the amount that) it affects the capital-output ratio (and hence the capital-labor ratio). Assuming that the technological progress $(\Delta A_t/A_t)$ is exogenous to the immigration process, the percentage change of average wages due to immigration can be expressed as a function of the percentage response of k_t or κ_t to immigration. Taking partial log changes of (6) relative to immigration we have:

$$\frac{\Delta w_t^L}{w_t^L} = (1-\alpha)\left(\frac{\Delta k_t}{k_t}\right)_{immigration} = \frac{1-\alpha}{\alpha}\left(\frac{\Delta \kappa_t}{\kappa_t}\right)_{immigration} \quad (7)$$

where $(\Delta k_t/k_t)_{immigration}$ is the percentage change in the capital-labor ratio due to immigration and $(\Delta \kappa_t/\kappa_t)_{immigration}$ is the percentage change of capital-output ratio due to immigration. It is straightforward to see that if immigration stimulates full capital adjustment within the considered period, so that the economy remains in balanced growth path, the two previous terms are 0, hence immigration does not change total wages. At the same time it is straightforward to see that if one assumes fixed total capital within the period $K_t = \overline{K}$, then $(\Delta k_t/k_t)_{immigration}$ equals the percentage change of employment due to immigration taken with a negative sign: $-\frac{\Delta F_t}{L_t}$, where ΔF_t is the increase in foreign-born workers in the considered period and L_t is the labor aggregate at the beginning of the period. In the extreme case in which we keep capital unchanged over fourteen years of immigration, 1990-2004, the inflow of immigrants, equal to roughly 11.5% of the initial labor force, combined with a share $(1-\alpha)$ equal to 0.33 implies a negative effect on average wages of 3.5 percentage points.

Given data on yearly capital-output ratios and on yearly immigration flows, however, we can estimate the actual response of capital-output ratio to immigration flows, allowing for sluggish adjustment of capital and use that, rather than the theoretical one, in the formula (7) above.

3.2.2 Estimated Capital-Adjustment to Immigration

We construct the variable $\kappa_t = (K_t/Y_t)$ dividing the stock of capital at current prices (Net Stock of Private and Government Fixed Assets from the Bureau of Economic Analysis, 2006) by the total Gross Domestic Product at current prices (also from Bureau of Economic Analysis, 2006) for each year during the period 1960-2004. We construct the change of employment due to immigration, $\frac{\Delta F_t}{L_t}$, for each year 1960-2004, using the following procedure. From the U.S. Department of Justice, Immigration and Naturalization Service, (2004) we obtain the number of (legal) immigrants for each fiscal year 1960-2004. We then distribute the net change of foreign-born workers in each decade (measured from census data and from the American Community Survey, which includes illegal immigrants as well as legal ones), over each year in proportion to the gross yearly flows of legal immigrants. This allows us to obtain ΔF_t for each year.Finally we use total non-farm employment at the beginning of the year from The Bureau of Labor Statistics (2006) to measure L_t[10]. Figure 1 shows the behavior over time of the Capital-Output ratio, κ_t, calculated as described above. It is also useful to show the behavior of the immigration rate, $\frac{\Delta F_t}{L_t}$, and of the percentage changes of Capital-Output, $\frac{\Delta \kappa_t}{\kappa_t}$ during the 1960-2004 period. Figure 2 reports those series: the solid line represents $\frac{\Delta F_t}{L_t}$ and the dashed line represents $\frac{\Delta \kappa_t}{\kappa_t}$. Two things are evident already from the graph. 1) Immigration rates are much smaller, gradual and likely to be predictable than changes in

[10] The exact measure of L_t would be the labor aggregate described in (2). We approximate it by using total employment.

κ_t.2) One cannot discern any pattern of opposite co-movements (negative correlation) of the two series which would be the case were capital fixed in the short-run. These two facts already cast doubts on the idea that even within a year immigration constitutes an "unpredicted" shock causing a decrease in κ_t. In particular, if K_t were fixed one would observe values of $\frac{\Delta\kappa_t}{\kappa_t}$ equal in size and opposite in sign than $\frac{\Delta F_t}{L_t}$. This does not seem to be the case neither for the magnitudes nor for the correlation of the series. More formally, assuming that $ln(\kappa_t)$ follows an $AR(1)$ process, which accounts for its potentially slow adjustment, we analyze wether, given its value in the previous year, $ln(\kappa_{t-1})$, the immigration rate $\frac{\Delta F_t}{L_t}$ affects $ln(\kappa_t)$ negatively. Our basic regression is:

$$\ln(\kappa_t) = \beta_0 + \beta_1 \ln(\kappa_{t-1}) + \gamma \frac{\Delta F_t}{L_t} + \varepsilon_t \tag{8}$$

Where ε_t are zero-mean uncorrelated shocks that affect κ_t independently from immigration. If capital does not respond at all to immigration within one year, then γ should equal -1. If capital fully adjusts to immigration in order to keep real return (and capital-output ratio) constant then γ should equal 0. If capital anticipates the inflow of immigrants or over-reacts to them in the short-run then γ could even be positive. The fact that capital adjusts within one year to immigration does not mean that capital would fully adjust to all shocks. It may be that immigration rates are predictable enough or small enough to be adjustable within the year, while other shocks (ε_t) may not be. Table 1 reports the results from estimating (8) and several variations of it. Specification 1 is exactly as (8). While the coefficient on lagged capital-output is large (0.9) showing high persistence of the variable κ_t[11], the coefficient on the immigration rate (γ) is equal to-0.14, much closer to 0 than to -1, very imprecisely estimated and not statistically significant. The estimated standard error is extremely large, probably due to the very small variance of the explanatory variable $\frac{\Delta F_t}{L_t}$ relative to the variance of the dependent variable $\ln(\kappa_t)$ (almost 10 times larger). If one believes the point estimate of specification 1 about 86% of the immigration shock is adjusted by capital within a year and only 14% affects negatively the capital-output (and capital-labor) ratio. Our method of distributing the decade-long net immigration across individual years risks to introduce some discontinuities in the first year of each decade. This, plus the fact that year 1991 appears to be an outlier (with a rate double than any other in the series), induce U.S. to estimate specification 2 controlling for a 1991 dummy. When doing so, the coefficient on the immigration rate becomes even positive and large, but still very imprecisely estimated. This jump and lack of precision, when changing one observation, confirms the extremely low correlation between immigration rates and changes in κ_t.Interpreting the very high persistence of $\ln(\kappa_t)$ as a potential sign of non-stationariety of $\ln(\kappa_t)$ we estimate the regression in differences, with $\Delta\ln(\kappa_t)$ regressed on $\frac{\Delta F_t}{L_t}$ (specification 3). Still the estimate of γ is positive (0.54), very imprecise and not significant. Going back to the specification in levels, column 4 focuses on the period with

[11] An augmented Dickey-Fuller test does not reject the hypothesis of unit root. However, in the long run the series κ_t appears rather stable over time.

highest immigration (after 1980). The point estimate of γ is even more positive (2.03) and less precise (standard error equal to 2.38) showing an even smaller correlation between $\frac{\Delta F_t}{L_t}$ and κ_t during the recent decades of high immigration. Specification 5 and 6 use change in immigration rates over 2 years as potential determinants of κ_t. Column 5 includes lagged immigration rates as regressors. This results in a positive and insignificant coefficient on contemporary immigration rates and in a negative insignificant coefficient on lagged immigration (the two coefficient have similar size so that they would offset each other). Specification 6 uses 2-year periods to calculate immigration rates and changes in κ_t. The coefficient γ is still positive (0.60) and very imprecisely estimated. Finally in specification 7 we consider the percentage growth of employment in a year ($\frac{\Delta L_t}{L_t}$) as the shock to which κ_t responds and we use immigration rates $\frac{\Delta F_t}{L_t}$ as instrument assuming that it captures the exogenous part of this shock. In this case we obtain a coefficient very close to 0 (0.04) and still a very large standard error (0.47).

Taking all these estimates together, except for specification 1, the estimated impact of immigration rates on κ_t is always larger than 0 and never significantly different from 0. hence, it seems consistent with the data to assume that $(\Delta\kappa_t/\kappa_t)_{immigration}$ equals 0 even within one year, and certainly for a ten (or fourteen) year period over which we simulate the impact on wages. Alternatively, however, we also take the negative estimate of γ (-0.14) from specification 1 and the estimates of the other parameters ($\beta_0 = 0.10$, $\beta_1 = 0.90$) and use equation 8 recursively, beginning at the BGP value for κ_t and using the actual values of $\frac{\Delta F_t}{L_t}$ during the 1990-2004 period to obtain the implied $(\Delta\kappa_t/\kappa_t)_{immigration}$ for those fourteen years[12]. In this case we obtain $(\Delta\kappa_t/\kappa_t)_{immigration} = -0.0056$ for the period 1990-2004. Combined with $\alpha = 0.66$ in expression (7) this would imply that average wage w_t^L decrease only by 0.28 percentage points in the short run during the 1990-2006 period. Even taking the most negative estimate of capital adjustment, but accounting properly for the distribution of immigration over years and the dynamics of capital, the negative impact of immigration on average wages in the short run is small enough that we can safely approximate it to 0. In particular that negative effect is about one tenth of the negative "short-run" effect obtained holding capital constant for one decade (as done by all previous literature).

3.3 Effects of Immigration on Wages

We now use the production function (1) to calculate the demand functions and wages for each type of labor at any point in time. Choosing output as the numeraire good, in a competitive equilibrium the (natural logarithm of) the marginal productivity of US-born workers (H) in group k, j, equals (the natural logarithm of) their wage:

[12] The excel code for this simple calculation is available upon request.

$$\ln w_{Hkjt} = \ln\left(\alpha A_t^{\frac{1}{\alpha}} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\delta}\ln(L_t) + \ln\theta_{kt} - \left(\frac{1}{\delta} - \frac{1}{\eta}\right)\ln(L_{kt}) + \ln\theta_{kjt} - \left(\frac{1}{\eta} - \frac{1}{\sigma_k}\right)\ln(L_{kjt}) + \ln\theta_{Hkjt} - \frac{1}{\sigma_k}\ln(H_{kjt}) \quad (9)$$

We assume that the relative efficiency parameters $(\theta_{kt}, \theta_{kjt}, \theta_{kjHt})$ as well as total factor productivity A_t depend on technological factors and therefore are independent from the supply of foreign-born.

Let us define the change in the supply of foreign-born due to immigration between two censuses in group k, j as $\Delta F_{kjt} = F_{kjt+10} - F_{kjt}$. We can use the demand function (9) to derive the effect on native wages of immigration. The overall impact of immigration on natives with education k and experience j can be decomposed in three effects that operate through L_{kjt}, L_{kt} and L_t. 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 each one of the terms L_{kjt}, L_{kt} and L_t in expression (9). Second, a change in the supply of foreign-born workers with education k and experience $i \neq j$ affects the wage of natives with identical education k but different experience j by changing the terms L_{kt} and L_t. Third, a change in the supply of foreign-born workers with education $m \neq k$ affects native workers with different education k only through a change in L_t. Aggregating the changes in wage resulting from immigration in each skill group as well as the response of κ_t to immigration produces for each home-born worker the wage change due to immigration. The exact expression of each of the effects described above is provided in Appendix A.

Before showing the formula for the *total* effect of immigration on the wage of a home born worker of education k and experience j, let us show the formula for a *partial* effect which has been particularly emphasized in the previous literature. If we only consider the impact of immigrants with education k and experience j on the wages of natives with identical education and experience, keeping the aggregates L_{kt} and L_t constant, we obtain what large part of the previous literature called "effect of immigrants on wages". This, in fact, measures a *partial* effect, keeping supply in all other skill groups constant and keeping constant the aggregates L_{kt} and L_t . 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 in a panel across groups over census years, controlling for year-specific effects (absorbing the variation of L_t) and education-by-year specific effects (absorbing the variation of L_{kt}) (e.g. Borjas 2003). The resulting partial elasticity expressed as the percentage variation of natives' wage $(\Delta w_{Hkjt}/w_{Hkjt})$ in response to a percentage variation of foreign employment in the group $(\Delta F_{kjt}/F_{kjt})$, is given by the following expression:

$$\varepsilon_{kjt}^{partial} = \left|\frac{\Delta w_{Hkjt}/w_{Hkjt}}{\Delta F_{kjt}/F_{kjt}}\right|_{L_{kt}, L_t \text{ constant}} = \left[\left(\frac{1}{\sigma_k} - \frac{1}{\eta}\right)\left(\frac{s_{Fkjt}}{s_{kjt}}\right)\right] \quad (10)$$

The variable s_{Fkjt} is the share of overall wages paid in year t to foreign workers in group k, j, namely $s_{Fkjt} =$

$\frac{w_{Fkjt}F_{kjt}}{\sum_m \sum_i (w_{Fmit}F_{mit}+w_{Hmit}H_{mit})}$.Analogously, $s_{kjt} = \frac{w_{Fkjt}F_{kjt}+w_{Hkjt}H_{kjt}}{\sum_m \sum_i (w_{Fmit}F_{mit}+w_{Hmit}H_{mit})}$ is the share of total wage bill, 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 $\left(\frac{1}{\eta} - \frac{1}{\sigma k}\right)\ln(C_{kjt})$ in (9). Under the standard assumption of the existing literature US- and foreign-born workers are perfect substitutes within group k, j ($\sigma_k = \infty$) and share the same efficiency ($\tau_{kjHt} = \tau_{kjFt}$ which implies $s_{Fkjt}/s_{kjt} = \varkappa_{Fkjt}/\varkappa_{kjt}$). Then, (10) simplifies to $\varepsilon_{kjt}^{partial} = -\frac{1}{\eta}$: the harder it is to substitute between workers with different levels of experience (i.e. the lower η), 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 $\frac{1}{\eta}$, 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 η and data on wages and employment, the *partial* elasticity $\varepsilon_{kjt}^{partial}$ can be easily calculated. The problem is that this elasticity 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 L_{kt} and L_t produced by immigration, for the fact that immigration alters the supply of foreign-born workers in all other education and experience groups and for the response of κ_t to immigration. Once we do so, and aggregate all the effects, the total effect of immigration on the wages of native workers in group k, j is given by the following expression:

$$\begin{aligned}\left(\frac{\Delta w_{Hkjt}}{w_{Hkjt}}\right)^{Total} = & \frac{1}{\delta}\sum_m\sum_i\left(s_{Fmit}\frac{\Delta F_{mit}}{F_{mit}}\right) + \left(\frac{1}{\eta}-\frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right)\sum_i\left(s_{Fkit}\frac{\Delta F_{kit}}{F_{kit}}\right) + \\ & + \left(\frac{1}{\sigma_k}-\frac{1}{\eta}\right)\left(\frac{1}{s_{kjt}}\right)\left(s_{Fkjt}\frac{\Delta F_{kjt}}{F_{kjt}}\right) + \frac{1-\alpha}{\alpha}\left(\frac{\Delta \kappa_t}{\kappa_t}\right)_{immigration}\end{aligned} \quad (11)$$

It is easy to provide an intuition for each term in expression (11), by referring to the labor demand equation (9). The term $\frac{1}{\delta}\sum_m\sum_i\left(s_{Fmit}\frac{\Delta F_{mit}}{F_{mit}}\right)$ 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 $\frac{1}{\delta}\ln(L_t)$ in (9) which is positive for $\delta > 0$. The term $\left(\frac{1}{\eta}-\frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right)\sum_i\left(s_{Fkit}\frac{\Delta F_{kit}}{F_{kit}}\right)$ is the additional negative effect on productivity generated by the supply of immigrants within the same education group. As those immigrants are closer substitutes for natives in group k, j due to similar education, they have an additional depressing effect on their wage. This effect operates through the term $\left(\frac{1}{\delta}-\frac{1}{\eta}\right)\ln(L_{kt})$ in (9) which is negative if $\eta > \delta$. Finally, the term $\left(\frac{1}{\sigma_k}-\frac{1}{\eta}\right)\left(\frac{1}{s_{kjt}}\right)\left(s_{Fkjt}\frac{\Delta F_{kjt}}{F_{kjt}}\right)$ 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 $\left(\frac{1}{\eta}-\frac{1}{\sigma k}\right)\ln(L_{kjt})$ in (9) and it is exactly the partial effect $\varepsilon_{kjt}^{partial}$ multiplied by the percentage change $\frac{\Delta F_{kjt}}{F_{kjt}}$. Finally the term $\frac{1-\alpha}{\alpha}(\Delta\kappa_t/\kappa_t)_{immigration}$ is the wage change due to capital adjustment. As we have seen in the previous section we can assume that it is equal to 0 both in the short as well as in the long run. Clearly, since the *total* effect aggregates the *partial* effect plus 40 other cross-effects (32 in the double summation and 8 in the single summation), it will be generally very different from $\varepsilon_{kjt}^{partial} * \frac{\Delta F_{kjt}}{F_{kjt}}$. In fact, when immigration is large in groups with education and experience different from k and j, the effect $\left(\frac{\Delta w_{Hkjt}}{w_{Hkjt}}\right)^{Total}$ tends to be positive while when immigration is large in the group with the same education and experience as k and j, the effect $\left(\frac{\Delta w_{Hkjt}}{w_{Hkjt}}\right)^{Total}$ tends to be negative. To the contrary the effect $\varepsilon_{kjt}^{partial} * \frac{\Delta F_{kjt}}{F_{kjt}}$ would always be negative for reasonable parameters values.

As they are not perfect substitutes for US-born workers, the impact of immigration on wages of foreign-born would be somewhat different. The percentage change in wages of foreign-born of education k and experience j as consequence of total immigration is:

$$\left(\frac{\Delta w_{Fkjt}}{w_{Fkjt}}\right)^{Total} = \frac{1}{\delta}\sum_m\sum_i\left(s_{Fmit}\frac{\Delta F_{mit}}{F_{mit}}\right) + \left(\frac{1}{\eta}-\frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right)\sum_i\left(s_{Fkit}\frac{\Delta F_{kit}}{F_{kit}}\right) + + \left(\frac{1}{\sigma_k}-\frac{1}{\eta}\right)\left(\frac{1}{s_{kjt}}\right)\left(s_{Fkjt}\frac{\Delta F_{kjt}}{F_{kjt}}\right) + \frac{1-\alpha}{\alpha}\left(\frac{\Delta\kappa_t}{\kappa_t}\right)_{immigration} - \frac{1}{\sigma_k}\frac{\Delta F_{kjt}}{F_{kjt}} \tag{12}$$

The first four terms of expression (12) are identical to those in (11). Immigration in all other skill groups (and capital adjustment) has the same effect on wages of home and foreign born in group k, j. The only difference comes from immigrants in the same k, j group and is represented by the final term $-\frac{1}{\sigma_k}\frac{\Delta F_{kjt}}{F_{kjt}}$. This term is negative and larger the smaller is σ_k . The term captures an extra negative impact of immigration on the wage of foreign-born, due to their perfect substitutability with immigrants in the same group. For $\sigma_k = \infty$ the effects of immigration on wages of workers in group k, j will be identical independently of their nativity.

Using the percentage changes in wage for each skill group we can then aggregate and find the effect of immigration on several average wages. Let us denote with $\varkappa_{Nkjt}$ the share of total employment represented by workers of nativity N $(= H, F)$ education k, experience j in year t.The average wage for the whole economy in year t, inclusive of US- and Foreign-born workers is given by the following expression: $\overline{w}_t = \sum_k\sum_j(w_{Fkjt}\varkappa_{Fkjt} + w_{Hkjt}\varkappa_{Hkjt})$. Similarly, the average wage of US-born workers only is: $\overline{w}_{Ht} = \sum_k\sum_j(w_{Hkjt}\varkappa_{Hkjt})/\sum_k\sum_j\varkappa_{Hkjt}$ while the average wage of foreign-born workers is: $\overline{w}_{Ft} = \sum_k\sum_j(w_{Fkjt}\varkappa_{Fkjt})/\sum_k\sum_j\varkappa_{Fk}$ these definitions we can calculate the percentage change in each of those average wages which turns out to be equal to the weighted average of percentage changes in wages of each skill group, when the weights are the wage shares of each group[13]. The percentage change in the average wage of US-born workers, therefore, is :

[13]Notice that the correct weighting to obtain the percentage change on *average wages* is the share in the wage bill and not the share in employment. Weighting by employment shares would systematically *over-weight* the wage-change of less skilled workers and *under-weight* the wage-change of highly skilled workers.

$$\frac{\Delta\overline{w}_{Ht}}{\overline{w}_{Ht}} = \frac{\sum_k \sum_j (\frac{\Delta w_{Hkjt}}{w_{Hkjt}} \frac{w_{Hkjt}}{\overline{w}_{Ht}} \varkappa_{Hkjt})}{\sum_k \sum_j \varkappa_{Hkjt}} = \frac{\sum_k \sum_j (\frac{\Delta w_{Hkjt}}{w_{Hkjt}}) s_{Hkjt}}{\sum_k \sum_j s_{Hkjt}} \tag{13}$$

Where $\frac{\Delta w_{Hkjt}}{w_{Hkjt}}$ represents the percentage change in the wage of home-born in group k, j due to immigration and its expression is given in (11). Similarly, the percentage change in the average wage of foreign-born workers is:

$$\frac{\Delta\overline{w}_{Ft}}{\overline{w}_{Ft}} = \frac{\sum_k \sum_j (\frac{\Delta w_{Fkjt}}{w_{Fkjt}} \frac{w_{Fkjt}}{\overline{w}_{Ft}} \varkappa_{Fkjt})}{\sum_k \sum_j \varkappa_{Fkjt}} = \frac{\sum_k \sum_j (\frac{\Delta w_{Fkjt}}{w_{Fkjt}}) s_{Fkjt}}{\sum_k \sum_j s_{Fkjt}} \tag{14}$$

Finally, by aggregating the total effect of immigration on the wages of all groups, natives and foreign, we can obtain the effect of immigration on the average U.S. wages:

$$\frac{\Delta\overline{w}_t}{\overline{w}_t} = \sum_k \sum_j \left(\frac{\Delta w_{Fkjt}}{w_{Fkjt}} \frac{w_{Fkjt}}{\overline{w}_{Ft}} \varkappa_{Fkjt} + \frac{\Delta w_{Hkjt}}{w_{Hkjt}} \frac{w_{Hkjt}}{\overline{w}_{Ht}} \varkappa_{Hkjt} \right) = \sum_k \sum_j \left(\frac{\Delta w_{Fkjt}}{w_{Fkjt}} s_{Fkjt} + \frac{\Delta w_{Hkjt}}{w_{Hkjt}} s_{Hkjt} \right) \tag{15}$$

Due to constant return to scale of the aggregate production function **??**, while some of the wage changes will be positive and other negative, when weighted by their wage shares the summation of those changes equals 0, hence the change in the overall average wage in (15) would be approximately 0. However, if home and foreign-born are not perfectly substitutable the overall effect on wage of home-born, $\frac{\Delta\overline{w}_{Ht}}{\overline{w}_{Ht}}$ need not be 0 but could be positive instead and the effect on average wage of foreign-born could be negative. Moreover, for large percentage changes in wages (which considering migration over a decade may certainly be the case) second order (non-zero) effects may be non negligible and even the overall average effect may differ somewhat from 0. We also adopt the same averaging procedure (weighting percentage changes by wage shares) in calculating the effect of immigration on specific groups of US-born . For instance, the changes in average wages of College Educated U.S. born workers is calculated as $\sum_j \left(\frac{\Delta w_{HCOGjt}}{w_{HCOGjt}} s_{HCOGjt} \right) / \sum_j s_{HCOGjt}$ and the change in average wage of High-school dropouts foreign-born is calculated as:$\sum_j \left(\frac{\Delta w_{FHSDjt}}{w_{FHSDjt}} s_{FHSDjt} \right) / \sum_j s_{FHSDjt}$ and so on.

4 Data Description and Preliminary Evidence

The data we use are from the integrated public use microdata samples (IPUMS) of the U.S. decennial Census and of the American Community survey (Ruggles et al, 2005). In particular we use the general (1%) sample for Census 1960, the 1% State Sample, Form 1, for Census 1970, the 5% State sample for the Censuses 1980 and 1990, the 5% Census Sample for year 2000 and the 1/239 American Community Survey (ACS) Sample for the year 2004. As those are all weighted samples we use the variable "personal weight" to construct all the average and aggregate statistics below. We consider people aged 17 to 65 not living in group quarters, 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 (in 2000 U.S. $) using the C.P.I.-based deflator across years. 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 and ACS 2004. Years of experience are calculated using the variable "age" and assuming that people without an high school degree enter the labor force at age 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[14]. 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_{Nkjt} for $N = \{H, F\}$, $k = \{HSD, HSG, COD, COG\}$ and $j = \{1, 2..., 8\}$) is calculated as the weighted average of individual wages in the cell using the personal weight ("perwt") assigned by the U.S. census. The total number of workers in each cell ($H_{kjt}$and F_{kjt}) is calculated as the weighted sum of workers belonging to that cell. These data allow us to construct the variables $\varkappa_{Nkjt}$ and s_{Nkjt}, the share of each group in the total wage bill and in total employment for each represented year t, and are used to estimate the parameters δ, η, σ_k needed to calculate the effects of immigration on wage of each worker. When estimating the structural parameters δ, η, σ_k we always use the whole panel of data 1960-2004. When we calculate/simulate the effect of immigration on real wages we focus on the most recent period 1990-2004. Before proceeding with the econometric analysis let us present some salient features of the immigration and wage data and some simple statistics suggesting the plausibility of the hypothesis of imperfect substitutability between U.S. and Foreign-born workers with similar skills.

Tables 2 and 3 report, respectively, the share of foreign-born workers in each education-experience group for each of the considered years and the real weekly wages (in 2000 U.S. $) for U.S. native workers in each education and experience group for each of the considered years. The wages for each group are calculated as described above. In the rows marked as "All Experiences" we report the total (average) value for the variables relative to the whole Educational Group. Two facts emerge even from a cursory look at the tables. First, Table 2, confirms that the distribution of foreign-born across educational groups has been uneven and increasingly so over the considered period. In year 2004 almost 35% of the workers with no degree were foreign-born, with some experience sub-groups counting more than 40% foreign-born. Following this group the one of college graduates shows the second highest concentration of foreign-born: almost 15% in the overall group, reaching 18% in some experience sub-groups. Differently, the group of college dropouts had only 9.5% of foreign-born workers and,

[14] To keep samples comparable across census years we use the categorical variables that measure weeks worked. The variable is available for each census year and is called "wkswork2". Individuals are assigned the middle value of the variable in the interval.

in some experience sub-groups those were less than 8% of the total. As well known, the relative distribution of foreign-born workers across educational groups in the U.S. has been U-shaped over the education spectrum and increasingly so over time. Foreign-born were, and increasingly are, over-represented among the groups of workers with lowest and highest education and are under-represented among the two intermediate groups. The second fact, emerging from Table 3, is the poor performance of real weekly wages of US-born workers without a high school degree, especially during the last two decades and a half. In contrast the performance of real wages of college educated has been spectacular, particularly during the last two decades and a half, with the two intermediate schooling groups performing in between.

In order to provide a synthetic and effective representation of the two facts described above, focussing on the most recent 14 years, we present 2 figures. Figure 3 shows the percentage growth of employment due to immigration for each of the four educational groups. The 3-D columns in light color represent immigrants for the 1990-2000 period as percentage of 1990 employment in each education group. The 3-D columns in dark color represent immigration flows during the 1990-2004 period as a percentage of initial employment. The graph confirms the U-shaped distribution of immigrants along the educational spectrum, with a more pronounced U-shape when we consider the longer period of immigration (1990-2004). Figure 4, on the other hand, shows the growth-rate of real wages of native workers, by education group. The light colored 3-D columns represent the real percentage change of yearly wages in the 1990-2000 period, the dark colored 3-D columns represent the 1990-2004 change. One sees very clearly the negative performance of real wages for the least educated (almost one percentage point loss in real wage each year) and the exceptional performance of real wages of college graduates (more than one percentage point gain each year). The natural questions stemming from these facts are: i) How much of the negative performance in the wage of native dropouts is due to the large immigration flow in that group? and how much of the College-High School Dropout wage gap widening is due to immigration? ii) Given that the average wage of U.S. natives grew by almost 17% in the 1990-2004 period, and overall immigration increased employment by almost 12%, would overall wage growth have been larger without the increase in labor supply due to immigration? We will address these questions in Section (6.3).

Before presenting the estimates of the structural parameters of our model, especially σ_k , the elasticity of substitution between U.S. and foreign-born, let us present two facts that seem to suggest imperfect substitutability between U.S. and foreign-born workers in production ($\sigma_k < \infty$). Even considering workers who have identical measurable human capital (education and experience), foreign- and US-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, information via networks 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 (i.e. an effect on relative wages when relative supply changes).

Differences in the occupational choice between natives and foreign-born with same education are illustrated in Table 4. Following Welch (1990) and Borjas (2003) we calculate the "index of congruence" in the choice of 180 occupations (from the variable "occupation 1950" homogenized across censuses definitions) between the group of native workers and the group of foreign-born workers with the same education . 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. The first column in the table reports such indices for each education group. By way of comparison, the remaining columns report the indices of congruence between natives in different education groups. The index of congruence between US- and foreign-born with identical education is between 0.6 and 0.7 a value comparable to the congruence between native high school dropouts and native high school graduates (value 0.68 reported in the second column of Table 4). Also (see Welch, 1979) such index is comparable to the congruence between U.S. born workers with different experience levels. Hence, given that an extensive literature shows imperfect substitutability between U.S. workers with different education and experience (Welch, 1979; Card and Lemieux, 2001), if part of imperfect substitutability is due to occupational choice we would also expect it to hold for natives and foreign-born with similar education.

A second interesting fact relative to the occupational choice of immigrants is that new immigrant tend to work disproportionately in those occupations where foreign-born are already over-represented. Possibly because of networking, information diffusion or type of skills required new immigrants are attracted to jobs and tasks already disproportionately occupied by previous immigrants. This implies a stronger wage competition (substitution) on those jobs than on other jobs, held by natives, which are sometimes complementary to those. This tendency can be captures by regressing the increase in the share of foreign-born employment in an occupation on the initial share of foreign-born workers in that occupation, as follows:

$$\Delta(sh_{t,t+n}^{For})_i = \alpha + \beta \left(sh_t^{For}\right)_i + \varepsilon_i \tag{16}$$

where $\Delta(sh_{t,t+n}^{For})_i$ is the change in the share of foreign-born working in occupation i between year t and year $t+n$, $\left(sh_t^{For}\right)_i$ is the share of foreign-born in occupation i in year t and ε_i is a zero-mean random error. A positive and significant estimate of β means that new immigrants tend to disproportionately staff jobs with already high density of immigrants (and mostly affect those wages). Table 5 reports the estimates of β for the period 1980-1990 (first column) and 1990-2004 (second column). The first row reports the results pooling data for workers in each of 4 schooling groups while the other rows report regression considering education group separately. For each period, and each group the coefficient β is estimated to be very significant and positive. Considering for instance the row relative to high school dropouts, an occupation such as "Farm Laborers" where foreign born represented 46 percent of employment in 1990, experienced during the 1990-2004 period an increase of that percentage larger by 20% than the occupation "Farm Managers" that only counted 6% of foreign-born in 1990. These two occupations have clearly significant complementarity (both types are needed to run a farm) and new immigrants mostly competed with existing ones for laborers (hurting their wages) while complemented US-born who work as Managers (possibly increasing demand for those). Similar stories can be told for several other occupations. This implies that new immigrants affected disproportionately occupations where old immigrants were already over-represented. This likely implies that the wages mostly affected by immigration within each education group were those of previous immigrants.

5 Parameter Estimates

5.1 Estimates of σ_k

The model developed in Section (3.1) 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:

$$\ln(w_{Hkjt}/w_{Fkjt}) = -\frac{1}{\sigma_k}\ln(H_{kjt}/F_{kjt}) + \ln(\theta_{Hkjt}/\theta_{Fkjt}) \tag{17}$$

which defines the relative labor demand for foreign and US-born workers in group k, j. Equation (17) 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 $\ln(\theta_{Hkjt}/\theta_{Fkjt})$.

Our estimation strategy works as follows. Due to technological reasons such as skill-biased technical change, sector biased technical change, increased international competition and others, over the period 1960-2004, the profiles of the returns to education and to experience have changed differently across occupations. Accordingly, we allow relative efficiency of U.S. and foreign-born, $\ln(\theta_{Hkjt}/\theta_{Fkjt})$, 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}). At the same time different education-experience groups may include U.S. and foreign-born workers of systematically heterogeneous quality, hence we control for experience by education fixed effects (D_{kj}).Conditional on these controls, we assume that the residual decennial changes in relative employment within each education-experience cell over time, $\ln(H_{kjt}/F_{kjt})$, are due to random supply shocks such as demographic factors and immigration intensity. Thus, using the IPUMS data from 1960 through 2004 we estimate the following regression:

$$\ln(w_{Hkjt}/w_{Fkjt}) = D_{kj} + D_{kt} + D_{jt} - \frac{1}{\sigma_k}\ln(H_{kjt}/F_{kjt}) + u_{kjt} \tag{18}$$

where u_{kjt} is a residual random, zero-mean disturbance. In total we use 192 observations (8 experience by 4 education groups over 6 years: 1960, 1970, 1980, 1990, 2000, 2004) and we include thirty-two education by experience D_{kj} fixed effects, twenty-four education by time, D_{kt} ,fixed effects and fourtyeight experience by time, D_{jt}, fixed effects. The variables w_{Hkjt}, w_{Fkjt}, H_{kjt}, F_{kjt} are constructed as described in section 4 above. Table 6 reports the estimates of the parameter $\frac{1}{\sigma_k}$. The first row of Table 6 reports the estimates when we impose the same elasticity of substitution between U.S. and foreign-born workers within each of the four education group ($\sigma_k = \overline{\sigma}$), while the following four rows report the estimates when we allow σ_k to differ by education group. Specifications 1 and 2 use all workers to calculate supply and wages of each group, specification 3 and 4 use male workers only to calculate wages, while still all workers in calculating the supplies. All four specifications are estimated using weighted OLS, weighting each observation by the total employment in the cell. Specifications 5 and 6 use unweighted least squares as estimation method; specifications 7 and 8 omit year 2004 (not a census year) and the initial year 1960 as immigration was extremely low before 1960 and foreign born a very small group in 1960. We also tried other sub-samples beginning with year 1980 or ending in year 2000 obtaining very similar results. The estimates of $\frac{1}{\overline{\sigma}}$ are highly significant, quite stable across specifications and always between 0.1 and 0.2. The specifications using yearly wages tend to produce somewhat larger estimates (between 0.15 and 0.2), while those using weekly wages give estimates between 0.10 and 0.13. The standard errors are, generally, around 0.04. The estimates as a whole strongly support the idea of imperfect substitutability between U.S. and foreign-born workers confirming our intuition. Moreover, the estimates imply an elasticity of substitution between the two groups within an education-experience cell between 5 and 10. Hence we observe imperfect substitutability but, reasonably, not to the extent observed between educational groups (usually credited with a $1.5 - 2.5$ elasticity of substitution) and only slightly above the one observed between experience groups for U.S. natives (estimated between 3 and 5)[15].

The remaining rows of Table 6 show that allowing σ_k to vary across education groups the estimates become somewhat more imprecise. However they are still significant at the 5% level in each specification and most of them are still between 0.1 and 0.2. We do not observe any clear pattern in differences of degree of substitution between groups. Interestingly, the group of high school dropouts exhibits estimates of $\frac{1}{\sigma_k}$ as large as (if not larger than) the other groups, confirming that imperfect substitutability between Foreign and U.S.-born workers is certainly a feature present also at low levels of education. The F-test of the hypothesis of equal elasticities across groups ($\sigma_{HSD} = \sigma_{HSG} = \sigma_{COD} = \sigma_{COG} = \overline{\sigma}$) is reported in the last row of Table 6 together with the

[15] See section 5.3 below for those estimates in our paper and in the literature.

p-value (in parenthesis) for rejecting the null. In no case, except for specification 7, can one reject the null of identical elasticities at usual confidence levels. As these results are confirmed using also grouping of foreign-workers by effective skills (next section) we will operate, in the remaining of the paper, under the assumption of equal elasticities $\overline{\sigma}$.

5.2 Effective Skills

By grouping U.S. and Foreign born individuals according to their years of working experience one could be mis-classifying the effective skills of foreign-born, assigning them to a group that is not their most natural term of comparison. Employers may value differently work experience accrued in the U.S. market from the one accrued abroad hence an immigrant with some experience abroad should be re-classified by evaluating the "effective" value of that experience in terms of U.S.-accrued experience. The most natural comparison (and competitor) for an immigrant with 10 years of experience abroad may be a U.S. worker with only 4 years of experience, if experience abroad generates only 40% as much accumulation of valuable skills for the U.S. market. This point is noted and developed in Borjas (2003), section VI, and is relevant to the present study too. If a re-classification by effective experience groups affects those differences between U.S. and foreign-born workers that are responsible for imperfect substitutability, the estimated elasticity of substitution σ may change when using effective skill groups. We deal with this issue in the same way as Borjas (2003) did. First, we split the years of working experience of immigrants between experience in the U.S. and experience abroad. We do this by using the variable "year of immigration"[16] which defines the year of entry in the US. As the variable is categorical the exact year of entry of an individual is chosen to be the year in the middle of the interval. In so doing we divide foreign born worker in two types: those who always worked in the U.S. (migrated before beginning their working period) and those who worked abroad for some years. We then use the "conversion" factors between foreign and U.S. experience calculated in Borjas (2003). Those factors are based on a wage regression that calculates (for 1980-1990) the wage growth associated with one year of working experience abroad, relative to the growth of wage associated with one year of working experience in the US. Specifically, for foreign-born who always worked in the U.S. no conversion is needed and one year of their experience equal one year of experience of a US-born. For immigrants who worked abroad, the years of experience abroad are multiplied by a factor of 0.4 while the years of experience in the U.S. are multiplied by a factor of 1.6 (Borjas, 2003, page 1356). This implies an "under-accumulation" of useful skills per year when working abroad and an over-accumulation (catching up) during the years of U.S. working experience. Once we have calculated the effective experience we group foreign workers in the usual 8 groups (0 to 40 years by 5-years cells) using this new variable. This re-classification does not change much the relative wages and relative supplies entering equation (18). The

[16] The variable is called "YRIMMIG" in the IPUMS notation.

partial correlation of the new variables with the original variables, even after controlling for all the dummies, is between 0.96 and 0.98. Table 7 shows the elasticities, $\frac{1}{\sigma_k}$, calculated using the new groupings. Each estimate is very close to the corresponding one in Table 6. The constrained estimates of the first row still range between 0.1 and 0.2 as well as, mostly, the unconstrained ones. Even in this case one cannot reject (except for specification 1) the hypothesis of equal elasticity across education groups at usual significance levels. While, for robustness purposes, we still produce in the next section the estimates of the other parameters (η and δ) using both simple and effective experience groupings, we do not find any relevant differences in our analysis when adopting the definition of "effective" skills.

5.3 Estimates of η and δ

Equation (18) allowed us to estimate the parameters σ_k. We can also use it to infer the systematic component of the efficiency terms θ_{Hkjt} and θ_{Fkjt}. In particular, those terms can be obtained from the estimates of the fixed effects $\widehat{D}_{kj}$, $\widehat{D}_{kt}$ and $\widehat{D}_{jt}$ as:

$$\widehat{\theta}_{Hkjt} = \frac{\exp(\widehat{D}_{kj})\exp(\widehat{D}_{kt})\exp(\widehat{D}_{jt})}{1+\exp(\widehat{D}_{kj})\exp(\widehat{D}_{kt})\exp(\widehat{D}_{jt})}, \widehat{\theta}_{Fkjt} = \frac{1}{1+\exp(\widehat{D}_{kj})\exp(\widehat{D}_{kt})\exp(\widehat{D}_{jt})} \tag{19}$$

where we have imposed the standardization that they add up to one. Using the values of $\widehat{\theta}_{Hkjt}$ and $\widehat{\theta}_{Fkjt}$ from above and the estimate $\widehat{\sigma}$ we can construct the aggregate labor input, following 4, as $\widehat{L}_{kjt} = \left[\widehat{\theta}_{Hkjt} H_{kjt}^{\frac{\widehat{\sigma}-1}{\widehat{\sigma}}} + \widehat{\theta}_{Fkjt} F_{kjt}^{\frac{\widehat{\sigma}-1}{\widehat{\sigma}}}\right]^{\frac{\widehat{\sigma}}{\widehat{\sigma}-1}}$. Indeed, the production function (1) and marginal pricing imply the following relationship between the compensation going to the composite labor input L_{kjt} and its supply:

$$\ln(\overline{W}_{kjt}) = \ln\left(\alpha A_t^{\frac{1}{\alpha}} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\delta}\ln(L_t) + \ln\theta_{kt} - \left(\frac{1}{\delta} - \frac{1}{\eta}\right)\ln(L_{kt}) + \ln\theta_{kj} - \frac{1}{\eta}\ln(L_{kjt}) \tag{20}$$

where $\overline{W}_{kjt} = w_{Fkjt}(F_{kjt}/L_{kjt}) + w_{Hkjt}(H_{kjt}/L_{kjt})$ is the average wage paid to workers in the education-experience group k, j and can be considered as the compensation to one unit of the composite input L_{kjt}[17]. Equation (20) provides the basis to estimate the parameter $\frac{1}{\eta}$ that measures the elasticity of relative demand for workers with identical education and different experience. Empirical implementation is achieved by rewriting it as:

$$\ln(\overline{W}_{kjt}) = D_t + D_{kt} + D_{kj} - \frac{1}{\eta}\ln(\widehat{L}_{kjt}) + e_{kjt} \tag{21}$$

where five period fixed effects D_t control for the variation of $\ln\left(\alpha A_t^{\frac{1}{\alpha}} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\delta}\ln(L_t)$, twenty-four time by education fixed effects D_{kt} control for the variation of $\ln\theta_{kt} - \left(\frac{1}{\delta} - \frac{1}{\eta}\right)\ln(L_{kt})$ and thirty two education by experience fixed effects D_{kj} capture the terms $\ln\theta_{kj}$ that we assume constant over time. Once we control for these

[17]The wage $\overline{W}_{kjt}$ is an average of the wages paid to US and foreign born workers in group k, j. The averaging weights are equal to the employment of each group relative to the composite L_{kjt} which are very close to their share of the employment of group k, j.

systematic shifts in demand our identifying assumption, closely tracking Borjas (2003), is that the remaining variation in employment of foreign-born is due to supply shifts. Under this assumptions we consistently estimate the coefficient $-\frac{1}{\eta}$ in regression (21) by 2SLS, using $\ln(F_{kjt})$, the supply of foreign-born workers in each group, as instrument for the variable $\ln(\widehat{L}_{kjt})$. Table 8 reports the estimated values of $\frac{1}{\eta}$.The first row of Table 8 reports the estimates based on yearly wages, while the second row uses weekly wages. Specification 1 of Table 8 uses the parameters estimated in specification 1 and 2 of Table 6 to construct $\overline{W}_{kjt}$ $\widehat{L}_{kjt}$.Specification 2 of Table 8 uses the parameters estimated in specification 1 and 2 of Table 7 (effective skill grouping) to construct $\overline{W}_{kjt}$ $\widehat{L}_{kjt}$. The estimated values of $\frac{1}{\eta}$ are between 0.2 and 0.3 with standard errors around 0.10. This implies a value of η between 3.3 and 5. These value are very similar to those previously estimated in the literature. The parameter η was first estimated in Card and Lemieux (2001). Their preferred estimates of $1/\eta$ 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 η between 4 and 5. Borjas (2003) also produces an estimate of $1/\eta$. He uses immigration as a supply shifter but assumes perfects substitutability between US- and foreign-born workers. His estimate is equal to 0.288 (with standard error 0.11), implying a value of η equal to 3.5. In order to check how sensitive is the estimate of η to imperfect substitutability between U.S. and foreign-born workers we also re-estimate the parameter η assuming $\sigma = \infty$ in the construction $\widehat{L}_{kjt}$. This is done in specification 3 and 4. The point estimates of $1/\eta$ decrease very slightly (by 0.02-0.03) and their difference with specification 1 and 2 is not significant.

Aggregating one level further, we can construct the CES composite $\widehat{L}_{kt}$ .We obtain the estimates $\widehat{\theta}_{kj}$ from the experience by education fixed effects in regression 21, as follows: $\widehat{\theta}_{kj} = \exp(\widehat{D}_{kj})/\sum_j \exp(\widehat{D}_{kj})$. Then we use the estimated values of η to construct, according to the formula (3), $\widehat{L}_{kt} = \left[\sum_{j=1}^{8} \widehat{\theta}_{kj} L_{kjt}^{\frac{\widehat{\eta}-1}{\widehat{\eta}}}\right]^{\frac{\widehat{\eta}}{\widehat{\eta}-1}}$.The chosen production function together with marginal pricing then implies that the compensation going to the labor input L_{kt} and its supply satisfy the following expression:

$$\ln(\overline{W}_{kt}) = \ln\left(\alpha A_t^{\frac{1}{\alpha}} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\delta}\ln(L_t) + \ln\theta_{kt} - \frac{1}{\delta}\ln(L_{kt}) \tag{22}$$

where $\overline{W}_{kt} = \sum_j \left(\frac{L_{kjt}}{L_{kt}}\right) \overline{W}_{kjt}$ is the average wage in education group k[18]. Following the same strategy as we did before, we use the above expression as the basis for the estimation of $\frac{1}{\delta}$. In so doing, we rewrite (22) as follows:

$$\ln(\overline{W}_{kt}) = D_t + (Time\ Trend)_k - \frac{1}{\delta}\ln(\widehat{L}_{kt}) + e_{kt} \tag{23}$$

[18] The weight for the wage of each group equals the size of the composite input for that education-experience cell, L_{kjt} relative to the size of the composite input for the whole education group L_{kt}. This is very similar to the share of group k, j in the employment of educational group k.

where the time dummies D_t absorb the variation of the terms $\ln\left(\alpha A_t^{\frac{1}{\alpha}} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\delta}\ln(L_t)$. and the terms $(Time\ Trend)_k$ are education-specific time trends. These control for the systematic component of the efficiency terms $\ln \theta_{kt}$ that are assumed to follow a time trend specific to each educational group. Conditional on these controls, our identifying assumption is that any other change in employment of foreign-born within a group is a supply shift. Hence, we can estimate the equation (23) by 2SLS using $\ln(F_{kt})$ (where $F_{kt} = \sum_j F_{kjt}$) as instrument for $\ln(L_{kt})$. Table 9 reports the estimates of $\frac{1}{\delta}$. The first row uses yearly wages in the calculations, while the second uses weekly wages. Specifications 1 and 2 of Table 9 use the estimated values of $\widehat{\eta}$ and of $\widehat{\theta}_{kj}$ from specifications 1 and 2 of Table 8 to construct $\widehat{L}_{kt}$ and $\overline{W}_{kt}$. Specifications 3 and 4 use $\eta = \infty$ and symmetric weights θ_{kj} to construct $\widehat{L}_{kt}$ and $\overline{W}_{kt}$ .The estimated values are mostly between 0.4 and 0.5 (with standard errors around 0.15), consistent with an elasticity of substitution across education groups around 2. 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 Ciccone and Peri (2005). The estimates for that parameter range between 1.4 and 2.5. 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.

5.4 Partial Effects of Immigration on Wages

Before using the estimated values of the parameters δ, η and σ and the formulas derived in section 3.3 to calculate the effects of immigration on wages let us use those estimates in order to point out an important caveat. Most existing empirical studies on the effect of immigration on wages (including Borjas, Freeman and Katz, 1997, Card 2001, Friedberg, 2001, Card, 2001, section IV of Borjas, 2003 -but not section VII- and Borjas, 2006) carefully estimate the partial elasticity of native wages to immigration within the same skill group (expressed in our 10) and treat it as "the effect of immigration on wages". As we illustrated above this is simply a partial effect unable to inform on the actual effect of immigration on wages, unless we consider the whole distribution of skills of immigrants, the cross effects and the effect of capital adjustment. More importantly, the partial elasticity (10) is likely to be negative in any reasonable model as long as immigrants are closer substitute to natives in the same group (education-experience) than they are to natives in other skill groups. Using estimates from Tables 6 and 8, the term $\left(\frac{1}{\sigma_k} - \frac{1}{\eta}\right)$ is calculated to be negative and between -0.10 and -0.20. This implies, for instance, that the percentage change in the wage of native workers in group k, j, $\Delta w_{Hkjt}/w_{Hkjt}$, would be between -1.1% and 2.2% in response to an inflow of immigrants equal to 11% of the initial employment in the group[19]. We used

[19]The value is calculated using formula (10) and multiplying the two sides by $\Delta F_{kjt}/F_{kjt}$ so that we obtain: $\Delta w_{Hkjt}/w_{Hkjt} = \left[\left(\frac{1}{\sigma_k} - \frac{1}{\eta}\right)\left(\frac{s_{Fkjt}}{s_{kjt}}\right)\frac{\Delta F_{kjt}}{F_{kjt}}\right]$. Then, notice that the term $\left(\frac{s_{Fkjt}}{s_{kjt}}\right)\frac{\Delta F_{kjt}}{F_{kjt}}$ is approximately equal to $\frac{\Delta F_{kjt}}{H_{kjt}+F_{kjt}}$ if the share of wage of foreign-born in group k, j is similar to its share of employment in that group. Using $\frac{\Delta F_{kjt}}{H_{kjt}+F_{kjt}} = 11\%$ and $-0.2 < \left(\frac{1}{\sigma_k} - \frac{1}{\eta}\right) < -0.1$ we obtain a real wage change $-2.2\% < \Delta w_{Hkjt}/w_{Hkjt} < -1.1\%$.

11% as this equals the inflow of immigrants in the 1990-2004 period as percentage of total initial employment. If one fails to notice the *partial* nature of the elasticity used in the calculations above, one could be tempted to generalize these findings saying that immigration caused a negative 1.1 to 2.2 percent change (1990-2004) on average wages of natives and that groups such as high school dropouts, for which the inflow of immigrants was as high as 20% of initial employment, lost as much as 4.4% of their wage. No such generalization is possible, however, as expression (10) only account for the effect on wages of immigrants in the same skill group, for fixed L_{kt}, L_{kjt} and omits all the cross-groups effects from immigrants in other skill groups. In fact (as we see in section 6.1, below) while sharing the same negative partial elasticity $\left(\frac{1}{\sigma} - \frac{1}{\eta}\right)$ wages of natives across groups have very different responses to immigration, some being positive and other being negative, due to the relative sizes of skill groups and the relative strength of cross-groups effects. Limiting our attention to the elasticity $\varepsilon_{kjt}^{partial}$ or even emphasizing this effect too much would be misleading in evaluating the effect of immigration on wages.

6 Immigration and Wages: 1990-2004

We are now ready for the third and final step in producing our estimates (simulations) of the effects of immigration on wages of U.S. and foreign-born workers. The first step of the procedure (Section 3) required to specify a production function and derive labor demand curves and the elasticity of wage to immigration for workers with different skills. The second step (Section 5) required to estimate the relevant structural parameters (elasticities of substitutions). The third step (this section) uses these estimates, in the formulas previously derived, in order to calculate the effects of immigrants on wages of U.S. and foreign-born in individual group as well as overall.

6.1 Calculated Effects on Wages

Table 10 contains all the relevant simulation results, relative to the impact of immigration for the 1990-2004 period on wages of U.S. and foreign born workers. We focus on this period as it is the most recent covered by available data and it is the period of largest immigration in the recent U.S. history. To obtain the simulated effects we proceeded as follows: First, using the formulas (11) and (12), the estimated parameters δ, η ,σ and the percentage change in foreign born workers by skill group ($\Delta F_{kj,1990-2004}/ F_{kj,1990}$), we calculate the percentage change of real wage for US-born and Foreign-born workers in each skill group (k, j). Then we obtain the average wage change in each education group for foreign and U.S.-born by weighting the percentage change of each experience sub-group by its wage share in the education group. This provides the entries in lines one to four and six to nine in Table 10. Then we average the changes across education groups for U.S. and Foreign-born, separately, again weighting them by their wage shares, as described in the formulas (13) and (14). Those values are reported in lines five and ten (those in bold fonts). Finally we average the changes for the two groups (US and Foreign-born workers), still using wage-share weights (as described in formula 15) to obtain the overall wage change, reported in the last row (also in bold fonts). The upper part of Table 10 is comparable with the results usually shown in the previous literature, that mostly focused on the effect of immigration on wages of US-born workers. The lower part of Table 10 reports the effects of immigration on wages of foreign-born, rarely considered in the previous literature. The six specifications (columns) of Table 10 are reported to better understand the differences in the effects on wages due to our new hypothesis of full capital adjustment in the short run and imperfect substitutability between U.S. and foreign-born. Column 6 simulates the effects under the traditional "short-run" assumptions: fixed capital and perfect substitutability between U.S. and Foreign born workers in each group k, j[20].Proceeding leftward to column 5, we replace the assumption of fixed capital with the estimated short-run capital adjustment and in column 4 we report the results under full capital adjustment. As our estimated short run capital adjustment is essentially equal to the long-run adjustment the results in specifications 4 and 5 are very similar. Hence, in the rest of the simulations, we consider the effects in the short and long run as equal. Columns 3 to 1 introduce the imperfect substitutability between U.S. and Foreign-born workers. Column 3 uses the highest estimate of σ (equal to 10), Column 2 uses the average estimate $\sigma = 6.6$, and column 1 uses the lowest estimate $\sigma = 5$.

Let us begin with a few general comments. The introduction of our novel features (fast capital adjustment and imperfect substitutability) reverse the effect of immigration on average wages of natives from negative to positive and reduces the adverse distributional effect of immigrants on wages of US-born workers, particularly the negative impact on native high school dropouts. Both effects are stronger the lower the substitutability between U.S. and foreign-born workers. While faster capital adjustment has a positive effect, already in the short-run, on the wages of all groups, imperfect substitutability improves the impact of immigration on average wages of natives at the expenses of worsening it on the wages other foreign-born. Moreover, imperfect substitutability also reduces the adverse distributional effects on the wages of natives. This is the consequence of the fact that immigrants disproportionately take jobs and occupations already staffed by foreign-born workers and mostly compete for those wages. If the negative effect on wages of foreign-born may seem large (on average -13.3% in specification 3) this is due to the massive inflow of immigrants 1990-2004 relative to the initial size of the foreign-born employment. Immigrants in the labor force have more than doubled in the period 1990-2004. Precisely foreign-born workers have increased by 140% ($\Delta F_{1990-2004}/F_{1990} = 1.4$) during that period. Hence with a wage elasticity of that group relative to the US-born group equal to 0.10 (in column 3 $\sigma = 10$, hence the relative wage elasticity $\frac{1}{\sigma} = 0.1$) one obtains a relative wage change of around 14%, split, as we see in column 3, in an increase of native wages by 1.2% and a decrease in wages of foreign-born by 13.3%. We will come back

[20]The formulas to obtain the elasticity of wages of each skill group to immigration under the assumption of fixed physical capital are given in Appendix (B).

later to the evidence of increasing wage differentials between U.S. and foreign-born. Now let us describe more carefully the impact of immigration on wages of natives. One of the largely "publicized" economic effects of immigration has been its negative impact on wages of least educated American workers (Borjas, 2003, Borjas and Katz, 2005). That result is the one reproduced in the first row of specification 6. U.S.-born dropouts lost 8% of their wage due to immigration in the 1990-2004 period. Almost half of that negative effect is due to the short-run assumption of fixed capital. Once we use the actual (full) adjustment we reduce the loss to 4.2-4.5%. Then, if we allow for less than perfect substitutability between native and foreign born (column 3, $\sigma = 10$) the loss is further halved (to 2.1) and if we use our average estimate of σ the less educated natives only lost 1.1% of their wage due to immigration. At the same time the whole negative effect on average U.S. wages (-3.7%, column 6) is due to the fixed capital hypothesis. If we use the actual/full adjustment hypothesis we obtain (essentially) no change in average wage of Natives. When we also include imperfect substitutability ($\sigma = 6.6$) US-born workers gain 1.8% in their average wage because of immigration. Moreover in specifications 1 to 3 all US-born workers with high school degree or more (accounting for 90% of the Native employment in 2004) gain. Our preferred specification, supported by our previous findings, is specification 2 in Table 10. We can see that relative to the traditionally estimated short-run effects (Column 6) the least educated workers only loose 1.1% of their real wage (vs. 8.0%) high school graduates with no college degree gain between 2.4 and 3.4%, and college graduates gain 0.7%. In the traditional short-run approach college graduate had a short-run loss of 5.4% and the other groups lost between 1.4 and 2.8%. Evidently our hypotheses, change deeply the effects of immigration on wages.

In our preferred specification (2) the real group of losers are foreign born workers, i.e. previous immigrants. On average they lost 19% of their real wages while some groups (College Graduates) lost up to 24% of their wage. Recall that, due to the assumption of constant return to scale in the aggregate production function, once capital fully adjusts to immigration (specification 1 to 4) the average overall wage (last row) does not change. Hence, our hypothesis of imperfect substitutability simply shifts the distributional effects of immigration by increasing the wage competition effect of immigrants on other foreign-born and decreasing it for US-born workers. Notice that if $\sigma=\infty$ the effects of immigration on wages are identical for U.S. and foreign born in the same education-experience group. The small differences reported in Column 4-6 between the effects on U.S. and Foreign-born wages are due to the different composition in employment distribution by experience and education between the two groups.

Are the effects on wages of foreign-born workers reasonable? First of all, even simply looking at relative US-foreign born wages there are some skill groups that experienced large immigrants inflow and a substantial deterioration of their wage relative to natives. For instance among the high school dropouts between 20 and 35 years of experience, until 1980 wages of U.S. and foreign born where almost identical, while in 2004 US-born were earning 15-20% more than foreign born workers. A similar relative decline can also be observed for high school graduates in the 20-30 years of experience. The worsening over decades of wages of foreign-born relative to US-born, especially for the recently arrived (see for instance Borjas 1999, page 27) usually attributed to worsening in quality of immigrants is interpretable, in the light of our results, as an effect of increased wage competition between foreign-born in those occupations that overwhelmingly employ immigrants. Second, the reason that we do not observe larger Native-foreign wage differentials in all skill groups is that probably immigrants choose sectors/occupation/jobs with booming demand so that the systematic components of θ_{Fkjt} by year and skill (that we controlled for in equation 18) partly offset the negative effect of increased supply. Finally, another reason why the efficiency term θ_{Fkjt} may vary to systematically offset the increase in supply of foreign-born, $\Delta F_{kj,1990-2004}$, has been proposed by Lewis (2005) and Card and Lewis (2005).Those sectors/job where immigrants skills (in terms of education and experience) are more abundant induce technological choices "biased" towards those skills and use them more effectively increasing the relative efficiency θ_{Fkjt}. The large negative effects on wages of other foreign-born are, therefore, in part offset by systematic improvements in relative efficiency.

Finally, let US provide an explanation of an apparent puzzle raised by our theory. In the light of our analysis previous immigrants are the group whose wage suffers most from new immigrants. Why, then, are they consistently among the strong supporters of more open immigration policies (see e.g. Hatton and Williamson, 2005 and Mayda, 2006)? Obviously, while they may forego as much as 1% wage growth per year due to new immigrants they are also the group that gains most from the non-economic point of view. As immigration (legal and illegal) in the U.S. works mostly through family re-union, network connections and personal ties new immigrants are likely to be spouses, siblings, friends and acquaintances of foreign-born residents in the U.S. and hence probably have a huge personal, affective and amenity value to them.

6.2 Robustness Checks

Table 11 shows the changes in the calculated effects when we use different values for the parameters δ and η in the simulations. While the values used in Table 10, equal to 2 and 4 respectively, seem to be right in the middle of the estimated range for these parameters (both in our estimates and in previous ones) some articles have estimated values of δ as low as 1.5 and as high as 2.5, while the range for η is between 3 and 5. We reproduce simulations from Column 1-3 of Table 10 using, respectively, the low estimates of δ and η (columns 1-3 in Table 11) and the high estimates of δ and η (columns 4-6 in Table 11). While the average effects on wages of native and foreign-born workers are not sensitive to changes in those parameters, the distributional effects between education groups become stronger when we use lower estimates of δ and η. Considering column 2 and 5 as the references, as they use the median estimate of σ, we see that the wage loss of U.S.-born high school dropouts can be as large as -2.5% when δ =1.5. Still this number is much smaller than the previous short-run estimates. On the other hand, if we use the higher elasticity of substitution estimates, unskilled natives barely suffer a loss of wage even in the short run (-0.3%) from immigration. A similar widening of the distributional effects takes place, using the lower estimates, for wages of foreign-born workers across education group. Similar consequences of widening the distributional effects would be observed if we lower δ and η in the simulation with fixed capital and $\sigma = \infty$. Hence in relative terms the effects of our hypothesis on wages of natives (positive average effect and smaller distributional impact) are preserved for any value of δ and η.

6.3 Contribution of Immigration to Average Wage and Wage Dispersion of US-born workers

The differences shown in Table 10 between specification 2 (our preferred one) and specification 6 (representative of previously estimated short-run effects) seem large and substantial. It is very instructive, in order to put them in perspective, to compare them with the actual changes in average wages of U.S.-born workers during the 1990-2004 period and with changes in the measures of their wage dispersion during the same period. Specification 2 implies an effect on average U.S. real wages 5.5% points larger than the usually estimated short-run effects in column 6 (+1.8% vs. -3.7%). This is a very large number even when compared to the overall growth of average wage of US-born workers in the period, which equals12.5% and is even more notable if compared to typical changes of real wages over the business cycle (amounting to less than 0.5%). Roughly two thirds of that difference is due to the hypothesis of fast capital adjustment while one third is due to the imperfect substitutability between U.S. and foreign-born workers.

Even more interestingly, as immigration has been connected to increased wage dispersion (e.g. Freeman, Borjas and Katz 1997 and several others), we can compare what fraction of that increase could be due to immigration. There are several ways of measuring wage dispersion across educational groups, depending on which group we focus on. Columns (1) and (2) of Table 12 provide some standard measures of increased wage dispersion across educational groups during the period 1990-2004. In particular, Column (2) reports, in the first four rows, the percentage variation of the real wage for each of the four groups relative to the average real increase of wages[21] and, in the last 2 rows, the table shows the real increase in the College/High School Dropouts wage premium and in the College/High School wage premium. All numbers are calculated for US-born workers only. Column 1 reports the actual percentage changes for each real wage group (not net of the average) showing that high school dropouts had actually real wage loss in the period. Notice first of all that wage dispersion increased between any two groups as lower wage groups (lower education groups) had lower growth rates of

[21] The average increase is calculated by weighting the percentage wage increases of each group by the average wage share of that group in the 1990-2004 period. It is different from the change in the average wage which also includes the effect of changes in educational shares.

wages. Particularly bad has been the performance of US-born high school dropouts whose wages dropped by 24.4% relative to the average during the period. Also sub-average (but much less so) were the performances of wages of high school graduates (6.1% lower than average) and college dropouts (4.1% lower than average). On the other hand wages of college graduates substantially out-performed the average (8.9% better). As a consequence the wage premium (in ratio) between college graduates and high school dropouts increased by 33% during the period and the College/High School wage premium increased by 15%. These statistics are calculated using Census and American Community Survey IPUMS data on wage of all US-born workers as defined in section 4. Columns (3) shows the percentage changes in real wages attributed to immigration by our model, (Specification 2 of Table 10) and column (4) shows what share they represent of the actual 1990-2004 change. Looking at the first four rows immigration actually decreased wage dispersion for three groups (HSG, COD and COG), in that it helped the first two groups, that performed worse than average and hurt the last one that performed better. As for natives High School Dropouts, immigration explains less than one eight (0.12) of the difference in performance of this group's wage with the average wage. As a consequence, immigration does not contribute at all to explain the increased college-high school wage premium, if anything immigration caused a reduction in that premium as the last row of column (3) and (4) show. On the other hand it only explains one twentieth (0.05) of the increase in college-high school dropout premium. These numbers seem to show that immigration cannot be considered as an important candidate in explaining increased wage dispersion. Even giving to immigration the best shot at causing wage dispersion by adopting the old assumption of $\sigma = \infty$[22] (column 5 and 6) one still obtains that immigration *attenuated* wage dispersion for three groups (helping those underpeforming the mean and hurting those outperforming it) and contributed to the under-performance of wages of high school dropouts. However, only one sixth (0.17) of their growth differential with the average wage and less than one tenth (0.087) of the increase in college-high school dropout premium can be attributed to immigration, even in this scenario.

7 Conclusions

The main message of this paper is that only within a model that specifies the interactions between workers of different skills and between them and physical capital in a production function can we derive marginal productivity, labor demands and analyze the effects of changes in supply of different skills (caused by immigration) on wages of different types of workers. The literature on immigration has paid an excessive attention to the estimates of the partial effect of immigrants on wages of U.S.-born workers with similar skills. Those estimates are, as we said, *partial* in that they assume constant supply of all other groups and therefore are not infor-

[22] Assumptions on capital adjustment do not have significant impact on relative wages but only on the average wage. Hence the relative changes in specification (3) and (5) could be either for fixed or for fully adjusted capital.

mative of the actual effects of immigration on wages. In taking the general equilibrium approach, instead, one realizes that the substitutability between U.S. and foreign-born workers with similar schooling and experience as well as the investment response to change in the supply of skills are important parameters to evaluate the short and long run effect of immigration on wages. We therefore tackle carefully the tasks of estimating the elasticity of substitution between U.S. and foreign-born workers as well as the extent of capital adjustment to immigration. We find strong and robust evidence that U.S. and foreign-born workers are not perfect substitute within an education experience group, probably due to their choice of jobs and occupations. We also find that investments respond fast and fully to immigration, already within one year. This implies an average benefit to wages of natives from immigration, already in the short run, distributed as a small loss to the group of high school dropouts and significant wage gains for all the other groups of U.S. natives. The group suffering the biggest loss in wage, rather than natives, is the one of previous immigrants, who compete for much more similar jobs and occupations with the new immigrants. Finally, our model implies that it is very hard to claim that immigration has been a significant determinant in the deterioration of wage distribution during the 1990's and 2000's. Only one eight of the sub-average wage performance of high-school dropouts in the 1990-2004 period can be attributed to immigration, while immigration helped wages of high school graduates (the second worst performers of the period). As 30% of U.S. workers are in the group of high school graduates (vis-a-vis only 10% in the High school dropout group) it may be reasonable to consider the college-high school wage premium as the most meaningful measure of wage dispersion. In this case immigration actually worked to reduce that wage gap in the 1990-2004 period.

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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 (11), 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 (9) 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 foreign-born in the same group ($\Delta F_{kj}/F_{kj} = \Delta \ln(F_{kj})$):

$$\frac{\Delta w_{Hkjt}}{w_{Hkjt}} = \left[\frac{1}{\delta} + \left(\frac{1}{\eta} - \frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right) + \left(\frac{1}{\sigma_k} - \frac{1}{\eta}\right)\left(\frac{1}{s_{kjt}}\right)\right] s_{Fkjt}\frac{\Delta F_{kjt}}{F_{kjt}} \tag{24}$$

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 (9) with respect to $\ln(F_{ki})$ we obtain:

$$\frac{\Delta w_{Hkjt}}{w_{Hkjt}} = \left[\frac{1}{\delta} + \left(\frac{1}{\eta} - \frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right)\right] s_{Fkjt}\frac{\Delta F_{kit}}{F_{kit}} \tag{25}$$

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 (9) with respect to $\ln(F_{mit})$ we obtain:

$$\frac{\Delta w_{Hkjt}}{w_{Hkjt}} = \frac{1}{\delta} s_{Fkjt}\frac{\Delta F_{mit}}{F_{mit}} \tag{26}$$

One can then easily combine the above effects to obtain the expression (11) reported in the text.

B Appendix: Elasticities assuming fixed physical capital

The standard "short-run" calculations assume constant physical capital in response to immigration ($K_t = \overline{K}$). In that case the expression of the wage of the domestic workers of experience j and education k is the following:

$$\ln(w_H)_{kjt} = \ln\left(\widetilde{A}\overline{K}^{1-\alpha}\right) + \left[\frac{1}{\delta} - (1-\alpha)\right]\ln(L_t) + \ln\theta_{kt} - \left(\frac{1}{\delta} - \frac{1}{\eta}\right)\ln(L_{kt}) + \ln\theta_{kjt} - \left(\frac{1}{\eta} - \frac{1}{\sigma_k}\right)\ln(L_{kjt}) + \ln\theta_{Hkjt} - \frac{1}{\sigma_k}\ln(H_{kjt}) \tag{27}$$

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 physical capital fixed is:

$$\left[\frac{\Delta w_{Hkjt}}{w_{Hkjt}}\right]^{partial}_{K_t=\overline{K}} = \left[\left(\frac{1}{\delta} - (1-\alpha)\right) + \left(\frac{1}{\eta} - \frac{1}{\delta}\right)\left(\frac{1}{s_{kt}}\right) + \left(\frac{1}{\sigma_k} - \frac{1}{\eta}\right)\left(\frac{1}{s_{kjt}}\right)\right] s_{Fkjt}\frac{\Delta F_{kjt}}{F_{kjt}} \tag{28}$$

and aggregating the effects of immigration in each skill group the total effect of immigration on wages of domestic workers in cell j, k is:

$$\left(\frac{\Delta w_{Hkjt}}{w_{Hkjt}}\right)^{Total} = \left[\frac{1}{\delta} - (1-\alpha)\right] \sum_m \sum_i \left(s_{Fmit} \frac{\Delta F_{mit}}{F_{mit}}\right) + \left(\frac{1}{\eta} - \frac{1}{\delta}\right) \left(\frac{1}{s_{kt}}\right) \sum_i \left(s_{Fkit} \frac{\Delta F_{kit}}{F_{kit}}\right) + \left(\frac{1}{\sigma_k} - \frac{1}{\eta}\right) \left(\frac{1}{s_{kjt}}\right) \left(s_{Fkjt} \frac{\Delta F_{kjt}}{F_{kjt}}\right) \quad (29)$$

Similarly for the wage of foreign-born workers in group k, j the impact of immigration assuming fixed capital is given by:

$$\left(\frac{\Delta w_{Fkjt}}{w_{Fkjt}}\right)^{Total} = \left[\frac{1}{\delta} - (1-\alpha)\right] \sum_m \sum_i \left(s_{Fmit} \frac{\Delta F_{mit}}{F_{mit}}\right) + \left(\frac{1}{\eta} - \frac{1}{\delta}\right) \left(\frac{1}{s_{kt}}\right) \sum_i \left(s_{Fkit} \frac{\Delta F_{kit}}{F_{kit}}\right) + \left(\frac{1}{\sigma_k} - \frac{1}{\eta}\right) \left(\frac{1}{s_{kjt}}\right) \left(s_{Fkjt} \frac{\Delta F_{kjt}}{F_{kjt}}\right) - \frac{1}{\sigma_k} \frac{\Delta F_{kjt}}{F_{kjt}}. \quad (30)$$

The difference with the case of full capital adjustment is the term $-(1-\alpha)\sum_m \sum_i \left(s_{Fmit} \frac{\Delta F_{mit}}{F_{mit}}\right)$ appearing in the wage of each group. One can easily see that the double summation is equal (approximately) the the inflow of immigrants relative to the initial total employment. Hence in a period as 1990-2004 when total immigrants inflow amounted to about 10% of employment in 1990, for a share of physical capital equal to 0.33 one would obtain a negative effect of 3.3% on the wage of each group of workers (and hence on the average) through this term.

Tables and Figures

Table 1
Response of K/Y to immigration rates

Specification:	1 Basic	2 Including 1991 Dummy	3 In Changes	4 Post 1980	5 2 lags of immigration	6 2-years intervals	7 Employment Change IV=Immigration rate
Lagged ln(K/Y)	0.90** (0.08)	0.89** (0.06)		0.86** (0.13)	0.89** (0.09)	0.82** (0.15)	0.90** (0.09)
Immigration rate	-0.14 (1.49)	1.06 (1.91)	0.54 (1.57)	2.03 (2.38)	0.88 (2.55)	0.60 (2.71)	
Lagged Immigration rate					-0.82 (1.21)		
% Change in Employment							0.04 (0.47)
Observations	44	44	44	24	44	22	44
R^2	0.80	0.81	0.01	0.87	0.82	0.80	0.80

Notes: Dependent variable is the natural logarithm of the Capital-Output Ratio, K/Y. Observations are yearly for the period 1960-2004. Method of estimation: OLS (except specification 7 estimated using 2SLS). **= significant at the 1% confidence level.

Table 2:
Share of Foreign Born Workers by Education and Experience

Group		Year					
Education	**Experience**	**1960**	**1970**	**1980**	**1990**	**2000**	**2004**
High School Dropouts	0 to 4	0.039	0.036	0.058	0.101	0.119	0.116
	5 to 9	0.061	0.060	0.138	0.264	0.375	0.354
	10 to 14	0.058	0.066	0.166	0.252	0.426	0.472
	15 to 19	0.056	0.072	0.143	0.262	0.416	0.493
	20 to 24	0.058	0.070	0.132	0.270	0.364	0.442
	25 to 29	0.055	0.061	0.124	0.222	0.363	0.377
	30 to 34	0.083	0.061	0.101	0.179	0.358	0.382
	34 to 40	0.122	0.058	0.086	0.161	0.281	0.345
	All Experiences	**0.07**	**0.060**	**0.109**	**0.205**	**0.306**	**0.341**
High School Graduates	0 to 4	0.019	0.025	0.032	0.057	0.095	0.107
	5 to 9	0.025	0.028	0.038	0.062	0.125	0.148
	10 to 14	0.028	0.033	0.046	0.057	0.118	0.167
	15 to 19	0.036	0.035	0.047	0.057	0.100	0.157
	20 to 24	0.035	0.037	0.051	0.062	0.085	0.119
	25 to 29	0.046	0.041	0.050	0.059	0.082	0.105
	30 to 34	0.065	0.040	0.051	0.060	0.081	0.097
	34 to 40	0.108	0.049	0.054	0.055	0.072	0.097
	All Experiences	**0.038**	**0.034**	**0.044**	**0.059**	**0.095**	**0.124**
College Dropouts	0 to 4	0.030	0.031	0.046	0.062	0.084	0.081
	5 to 9	0.042	0.047	0.051	0.071	0.097	0.104
	10 to 14	0.048	0.054	0.058	0.066	0.103	0.110
	15 to 19	0.055	0.058	0.065	0.063	0.095	0.117
	20 to 24	0.048	0.054	0.070	0.065	0.084	0.101
	25 to 29	0.052	0.058	0.065	0.070	0.076	0.087
	30 to 34	0.076	0.046	0.067	0.074	0.074	0.077
	34 to 40	0.099	0.057	0.067	0.072	0.077	0.076
	All Experiences	**0.052**	**0.048**	**0.057**	**0.067**	**0.088**	**0.095**
College Graduates	0 to 4	0.035	0.035	0.042	0.070	0.121	0.114
	5 to 9	0.045	0.064	0.062	0.090	0.143	0.173
	10 to 14	0.053	0.069	0.080	0.094	0.153	0.178
	15 to 19	0.056	0.060	0.097	0.087	0.138	0.160
	20 to 24	0.052	0.053	0.088	0.093	0.120	0.149
	25 to 29	0.064	0.058	0.073	0.107	0.105	0.126
	30 to 34	0.071	0.056	0.072	0.095	0.105	0.104
	34 to 40	0.088	0.070	0.072	0.088	0.125	0.122
	All Experiences	**0.054**	**0.056**	**0.070**	**0.089**	**0.128**	**0.146**

Note: Individuals included in calculations are those between 17 and 65 years, not living in group quarters, who received non-zero income and worked at least one hour per week and at least one week previous year. Foreign-born are workers born outside of the US and not citizen at birth. Sources: Authors' Calculations on individual data from Census IPUMS and ACS from Ruggles et al (2006).

Table 3:
Weekly Wages of U.S. Natives in constant 2000 U.S.$ by Education and Experience

Group		Year					
Education	**Experience**	**1960**	**1970**	**1980**	**1990**	**2000**	**2004**
High School Dropouts	0 to 4	207	246	207	180	214	179
	5 to 9	324	384	370	358	406	357
	10 to 14	377	442	415	423	480	446
	15 to 19	403	452	444	455	507	489
	20 to 24	401	468	471	476	554	548
	25 to 29	403	486	482	500	579	549
	30 to 34	399	470	494	522	594	599
	34 to 40	402	463	500	521	608	585
	All Experiences	**374**	**431**	**495**	**402**	**424**	**400**
High School Graduates	0 to 4	307	355	334	313	350	325
	5 to 9	404	476	439	437	485	457
	10 to 14	454	526	487	504	553	567
	15 to 19	472	538	526	537	606	631
	20 to 24	484	546	544	559	642	645
	25 to 29	486	551	552	596	658	658
	30 to 34	485	565	560	606	665	681
	34 to 40	476	556	558	587	681	673
	All Experiences	**463**	**501**	**478**	**507**	**579**	**576**
College Dropouts	0 to 4	354	402	365	359	388	374
	5 to 9	473	565	495	522	571	570
	10 to 14	543	639	573	604	665	686
	15 to 19	574	672	631	656	731	755
	20 to 24	583	694	649	708	775	794
	25 to 29	573	706	660	749	805	846
	30 to 34	567	715	670	757	836	820
	34 to 40	572	669	666	731	855	832
	All Experiences	**516**	**593**	**537**	**600**	**685**	**693**
College Graduates	0 to 4	469	573	477	569	658	645
	5 to 9	611	763	639	786	904	976
	10 to 14	728	908	798	932	1155	1230
	15 to 19	779	983	906	1024	1287	1349
	20 to 24	776	1036	964	1147	1318	1357
	25 to 29	779	1038	992	1203	1340	1365
	30 to 34	789	996	997	1213	1430	1347
	34 to 40	782	950	953	1178	1413	1336
	All Experiences	**693**	**863**	**761**	**950**	**1170**	**1201**

Note: Individuals included in calculations are those between 17 and 65 years, not living in group quarters, who received non-zero income and worked at least one hour per week and at least one week last year. Wages are in real US Dollars calculated using the CPI deflator with 2000 as base year. Foreign-born are workers born outside of the US and not citizen at birth. Sources: Authors' Calculations on individual data from Census IPUMS and ACS from Ruggles et al (2006).

Table 4
Index of Congruence in the choice of Occupations, Census 2004

Index of Congruence	Foreign, Same Education	Natives HSD	Natives HSG	Natives COD	Natives COG
Natives, HSD	0.65	1			
Natives, HSG	0.68	0.68	1		
Natives, COD	0.61	-0.25	0.22	1	
Natives, COG	0.70	-0.73	-0.91	0.35	1

Note: The Index of Congruence between the two groups (row and column headers) is calculated as the centered correlation coefficient (between -1 and +1) using 180 occupations, and data from the 2004 American Community Survey in Ruggles et al. (2006).

Table 5
Increasing specialization of foreign-born

Dependent Variable: Growth in share of foreign-born in the occupation			
Period:		1980-1990	1990-2004
Explanatory variable: Initial share of foreign-born in the occupation	**All Education groups, pooled**	0.69** (0.09)	0.64** (0.05)
	High School dropouts	0.65** (0.10)	0.50** (0.09)
	High School Graduates	0.31** (0.07)	0.96** (0.13)
	College Dropouts	0.88** (0.05)	0.30** (0.08)
	College Graduates	0.88** (0.09)	0.35** (0.06)

Note: Each cell reports the coefficient from a separate regression. The growth in the share of foreign-born employment in each occupation is regressed on its initial value.

Table 6
Relative U.S.-Foreign-Born Wage Elasticity within Education-Experience Cells

	All Workers,		**Male only**		**Not weighted**		**Omitting 1960, 2004**	
Specification	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Dependent variable	**Yearly Wages**	**Weekly Wages**	**Yearly Wages**	**Weekly Wages**	**Yearly Wages**	**Weekly Wages**	**Yearly Wages**	**Weekly Wages**
$1/\overline{\sigma}$	0.17**	0.11**	0.18**	0.10**	0.15**	0.13**	0.20**	0.11**
	(0.04)	(0.04)	(0.06)	(0.04)	(0.05)	(0.03)	(0.05)	(0.04)
$1/\sigma_{HSD}$	0.19**	0.11**	0.18**	0.08**	0.15**	0.10**	0.27**	0.10**
	(0.06)	(0.04)	(0.07)	(0.04)	(0.07)	(0.04)	(0.06)	(0.04)
$1/\sigma_{HSG}$	0.17**	0.14**	0.17**	0.09**	0.14**	0.12**	0.15**	0.08**
	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.05)	(0.04)
$1/\sigma_{COD}$	0.19**	0.12**	0.23**	0.16**	0.19**	0.15**	0.18**	0.13**
	(0.05)	(0.05)	(0.06)	(0.07)	(0.07)	(0.06)	(0.07)	(0.06)
$1/\sigma_{COG}$	0.10**	0.08**	0.12**	0.09	0.19**	0.13**	0.10**	0.08**
	(0.04)	(0.04)	(0.06)	(0.06)	(0.07)	(0.06)	(0.04)	(0.04)
Observations	192	192	192	192	192	192	128	128
Test F, All σ are equal	0.98	1.47	0.89	1.88	0.61	0.48	5.4	1.36
(p-value)	(41%)	(24%)	(45%)	(15%)	(67%)	(69%)	(1%)	(27%)

Notes: All Regressions include 32 education by experience fixed effects, 24 education by year fixed effects and 48 experience by year fixed effects. Errors are heteroskedasticity robust and clustered by education experience group. Dependent Variable is natural logarithm of relative wage of US and foreign born workers in the same education and experience group, the explanatory variable is the relative employment of US and foreign-born workers in the same education experience group. Observations are weighted by total employment in the cell, in all specifications except for 5 and 6.
In Specifications 1 and 2 the wages are calculated including all workers in the cells. In specifications 3 and 4 the wages are calculated including only Males in each cell. Specification 7 and 8 omit years 1960 and 2004. The F-statistic in the last row tests the hypothesis that all the elasticities of relative demand between US and foreign born worker are identical across educational group.

Table 7
Relative U.S.-Foreign-Born Wage Elasticity within Education-Experience Cells
Foreign-born are grouped by Effective Experience

	All Workers,		**Male only**		**Not weighted**		**Omitting 2004**	
Specification	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Dependent variable	**Yearly Wages**	**Weekly Wages**	**Yearly Wages**	**Weekly Wages**	**Yearly Wages**	**Weekly Wages**	**Yearly Wages**	**Weekly Wages**
$1/\overline{\sigma}$	0.17** (0.05)	0.12** (0.04)	0.18** (0.06)	0.10** (0.05)	0.16** (0.05)	0.13** (0.05)	0.16** (0.06)	0.10* (0.04)
$1/\sigma_{HSD}$	0.21** (0.06)	0.14** (0.07)	0.24** (0.08)	0.11 (0.07)	0.19** (0.06)	0.16** (0.07)	0.17** (0.05)	0.10** (0.05)
$1/\sigma_{HSG}$	0.18** (0.05)	0.16** (0.07)	0.17** (0.07)	0.09 (0.05)	0.17** (0.05)	0.17** (0.05)	0.19** (0.07)	0.13** (0.06)
$1/\sigma_{COD}$	0.20** (0.08)	0.12** (0.06)	0.20** (0.08)	0.13** (0.05)	0.18** (0.09)	0.13** (0.06)	0.24** (0.09)	0.12** (0.05)
$1/\sigma_{COG}$	0.10** (0.05)	0.08** (0.04)	0.10** (0.05)	0.07* (0.04)	0.11** (0.05)	0.08** (0.04)	0.11** (0.05)	0.07* (0.04)
Observations	160	160	160	160	160	160	128	128
Test F, All σ are equal (p-value)	4.12 (2%)	1.50 (22%)	2.6 (6%)	1.40 (26%)	2.4 (8%)	2.03 (13%)	2.3 (9%)	1.30 (32%)

Notes: Effective experience for foreign-born workers is calculated by weighting each year of their experience abroad by 0.4 and each year of experience in the US by 1.4. These "conversion factors" are estimated in Borjas (2003) using individual wages data. Period is 1970-2004 as in 1960 there is no information on the year when immigrants entered the country. All Regressions include 32 education by experience fixed effects, 20 education by year fixed effects and 40 experience by year fixed effects. Errors are heteroskedasticity robust and clustered by education experience group. Dependent Variable is natural logarithm of relative wage of US and foreign born workers in the same education and experience group, the explanatory variable is the relative employment of US and foreign-born workers in the same education experience group. Observations are weighted by total employment in the cell, in all specifications except for 5 and 6.
In Specifications 1 and 2 the wages are calculated including all workers in the cells. In specifications 3 and 4 the wages are calculated including only Males in each cell. Specification 7 and 8 omit year 2004. The F-statistic in the last row tests the hypothesis that all the elasticities of relative demand between US and foreign born worker are identical across educational group.

Table 8
Estimates of $1/\eta$, Relative Wage Elasticity Across Experience Cells

	CES Foreign-U.S.- born Using Estimated σ		**Simple Sum Foreign- U.S.-born (imposing σ=∞)**	
Specification	**1**	**2**	**3**	**4**
Skill groups	**Education- Experience cells**	**Education- Effective Experience cells**	**Education- Experience cells**	**Education- Effective Experience cells**
Yearly Wages	0.30**	0.21**	0.26**	0.20**
	(0.10)	(0.09)	(0.07)	(0.07)
Weekly Wages	0.29**	0.19**	0.25**	0.16**
	(0.10)	(0.08)	(0.07)	(0.06)
Observations	192	160	192	160

Notes: Method of estimation is 2SLS using the log of foreign-born employed in the education experience group as instrument for the variable $\ln(L_{kjt})$ that is constructed as described in the text. All regressions include 32 education by experience fixed effects and 24 education by year fixed effects. Specifications 2 and 4 use effective experience groups and include only years 1970, 1980, 1990, 2000 and 2004. Specification 1 and 3 use the regular experience groups and include data for 1960 as well. In Parenthesis we report the Heteroskedasticity Robust Standard error clustered by education group

Table 9
Estimates of $1/\delta$, Relative Wage Elasticity Across Education Cells

$1/\delta$	**CES across experience groups, estimated η**		**Simple Sum across experience groups (imposing η=∞)**	
Specification	**1**	**2**	**3**	**4**
Skill Groups	**By Education-Experience**	**By Education-Effective Experience**	**By Education-Experience**	**By Education-Effective Experience**
Yearly wages	0.48**	0.42**	0.54**	0.40**
	(0.14)	(0.13)	(0.19)	(0.16)
Weekly Wages	0.49**	0.43**	0.54**	0.38**
	(0.15)	(0.12)	(0.18)	(0.16)
Observations	24	20	24	20

Notes: Method of estimation is 2SLS using the log of foreign-born employed in the education group as instrument for the variable $\ln(L_{kt})$ that is constructed as described in the text. All regressions include 4 time fixed effects and 4 education-specific time trends. Specifications 2 and 4 use effective experience groups and include only years 1970, 1980, 1990, 2000 and 2004. Specification 1 and 3 use the regular experience groups and include data for 1960 as well. In parenthesis we report the Heteroskedasticity Robust Standard error clustered by Education group

Table 10
Calculated Percentage Changes in Real Wages due to Immigrants Inflows, 1990-2004

Assumptions:	**Fully Adjusted Capital** , Estimated Elasticity Between U.S.- Foreign-Born, σ			**Fully Adjusted Capital**; Perfect Substitutability U.S.- Foreign-Born	**Estimated short-run adjustment of Capital**; Perfect Substitutability U.S.- Foreign-Born	**Fixed Capital;** Perfect Substitutability U.S.- Foreign- Born
Specification	1	2	3	4	5	6
Estimates of σ	Low σ=5	Median σ=6.6	High σ=10	σ , imposed = ∞	σ , imposed = ∞	σ , imposed = ∞
	% Real Wage Change of Us Born Workers due to immigration, 1990-2004					
HS dropouts US-born	-0.2%	-1.1%	-2.1%	-4.2%	-4.5%	-8.0%
HS graduates, US-born	+2.9%	+2.4%	+2.0%	+1.0%	+0.7%	-2.8%
CO dropouts, US-born	+3.7%	+3.4	+3.1%	+2.4%	+2.1%	-1.4%
CO graduates, US-born	+1.4%	+0.7%	0.0%	-1.5%	-1.8%	-5.4%
Average, US-born	**+2.3%**	**+1.8%**	**+1.2%**	**+0.1%**	**-0.19%**	**-3.7%**
	% Real Wage Change of Foreign Born Workers due to immigration, 1990-2004					
HS dropouts Foreign-born	-20%	-16.2%	-12.3%	-4.4%	-4.7%	-8.3%
HS graduates, Foreign-born	-31%	-23%	-15%	+1.0%	+0.7%	-2.8%
CO dropouts, Foreign-born	-17%	-12%	-7.3%	+2.4%	+2.1%	-1.4%
CO graduates, Foreign-born	-31%	-24%	-16%	-1.6%	-1.9%	-5.5%
Average Foreign-born	**-26%**	**-19%**	**-13.3%**	**-0.9%**	**-1.1%**	**-4.7%**
Overall Average: Native and US Born	**0%**	**0%**	**0%**	**0%**	**-0.28%**	**-3.8%**

Note: Values of the other parameters used in the estimation: δ=2, η=4, α=0.66. The inflow of immigrants in the period 1990-2004 as percentage of initial employment in the group were as follows: High School Dropouts: 20%, High School Graduates: 9.9%, College Dropouts: 6.5%, College Graduates: 14.1%, Overall 11.5%. The percentage change for the wage of each worker in group k, j is calculated using the formula (11) for US born and (12) for foreign-born. Then percentage wage changes are averaged across experience groups using the wage-share of the group in 1990 to obtain the Table entries. The averages for US and Foreign-born are obtained averaging the change of each education group weighted by its share in wage (as described in formulas 13 and 14). The overall average wage change adds the change of US and foreign-born weighted for the relative wage shares in 1990 (equal to 8.5% for foreign-born and 91.5% for US born).

Table 11
Robustness Checks, for our preferred specification with full capital adjustment in the short and long run

Value of δ	1.5			2.5		
Value of η	3			5		
Specification Value of σ_k	1 Low σ=5	2 Median σ=6.6	3 High σ=10	4 Low σ=5	5 Median σ=6.6	6 High σ=10
% Real Wage Change of Us Born Workers due to immigration, 1990-2004						
HS dropouts US-born	-1.6%	-2.5%	-3.5%	+0.6%	-0.3%	-1.3%
HS graduates, US-born	+3.3%	+2.8%	+2.3%	+2.7%	+2.2%	+1.8%
CO dropouts, US-born	+4.6%	+4.2%	+3.9%	+3.2%	+2.9%	+2.6%
CO graduates, US-born	0.9%	+0.2%	-0.6%	+1.7%	+1.0%	-0.2%
Average, US-born	**+2.3%**	**+1.8%**	**+1.2%**	**+2.3%**	**+1.8%**	**+1.2%**
% Real Wage Change of Foreign Born Workers due to immigration, 1990-2004						
HS dropouts Foreign-born	-21.0%	-17.8%	-14.0%	-19.3%	-15.3%	-11.4%
HS graduates, Foreign-born	-31.2%	-23.3%	-15.0%	-31.5%	-23.4%	-15.3%
CO dropouts, Foreign-born	-16.1%	-11.2%	-6.4%	-17.5%	-12.7%	-7.8%
CO graduates, Foreign-born	-32%	-24.8%	-17%	31.1%	-23.8%	-16%
Average Foreign-born	**-26%**	**-19.6%**	**-13.6%**	**-26%**	**-19.6%**	**-13.6%**
Overall Average: Native and Foreign-Born	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**

Note: Inflow of immigrants in the period 1990-2004 as percentage of initial employment in the group: High School Dropouts: 20%, High School Graduates: 9.9%, College Dropouts: 6.5%, College Graduates: 14.1%, Overall 11.5%. The formulas used to obtain single entries and averages are identical to those used in Table 10. The method used to construct the percentage changes in wages is identical to the one used in table 10.

Table 12
Effect of Immigrants on Real Wage Dispersion of US natives, 1990-2004

	(1) Actual Percentage Change 1990-2004	(2) Percentage Change relative to the average	(3) Percentage Change (relative to the average change) due to Immigration, Our model σ=6.6	(4) Share of (2) explained by (3)	(5) Percentage Change (relative to the average change) due to Immigration σ=∞	(6) Percentage of (2) explained by (5)
Real percentage Changes in Wages of Education Groups 1990-2004						
Real Wage of US-born, HS dropouts	-11.9%	-24.4%	-2.9%	0.12	-4.3%	0.17
Real Wage of US-born HS graduates	6.5%	-6.1%	+0.6%	-0.098 Attenuate Dispersion	+0.9%	-0.15 Attenuate Dispersion
Real Wage of US-born CO dropouts,	8.5%	-4.1%	+1.4%	-0.34 Attenuate Dispersion	+2.3%	-0.56 Attenuate Dispersion
Real Wage of US-born, CO graduates	21.5%	+8.9%	-1.1%	-0.12 Attenuate Dispersion	-1.4%	-0.015 Attenuate Dispersion
Real percentage Changes in Wage Premia, 1990-2004						
College/High School Dropout Wage Premium	+33.3%	+33.3%	+1.8%	0.05	+2.9%	0.087
College/High School Graduates Wage Premium	+15%	+15%	-1.7%	-0.11 Attenuate Dispersion	-2.3%	-0.15 Attenuate Dispersion

Notes: The wages for each group are calculated considering all US-born workers between the ages of 17 and 65, from the IPUMS Census 1990 and the IPUMS American Community Survey 2004 as described in the main text. CPI deflator is used to convert the wages in constant 2000 $. The Average growth of real wages between 1990 and 2004 was 12.5%. It is calculated weighting the percentage increases in real wage of each education group by their average wage shares in the period 1990-2004.

Figure 1
Capital-Output Ratio

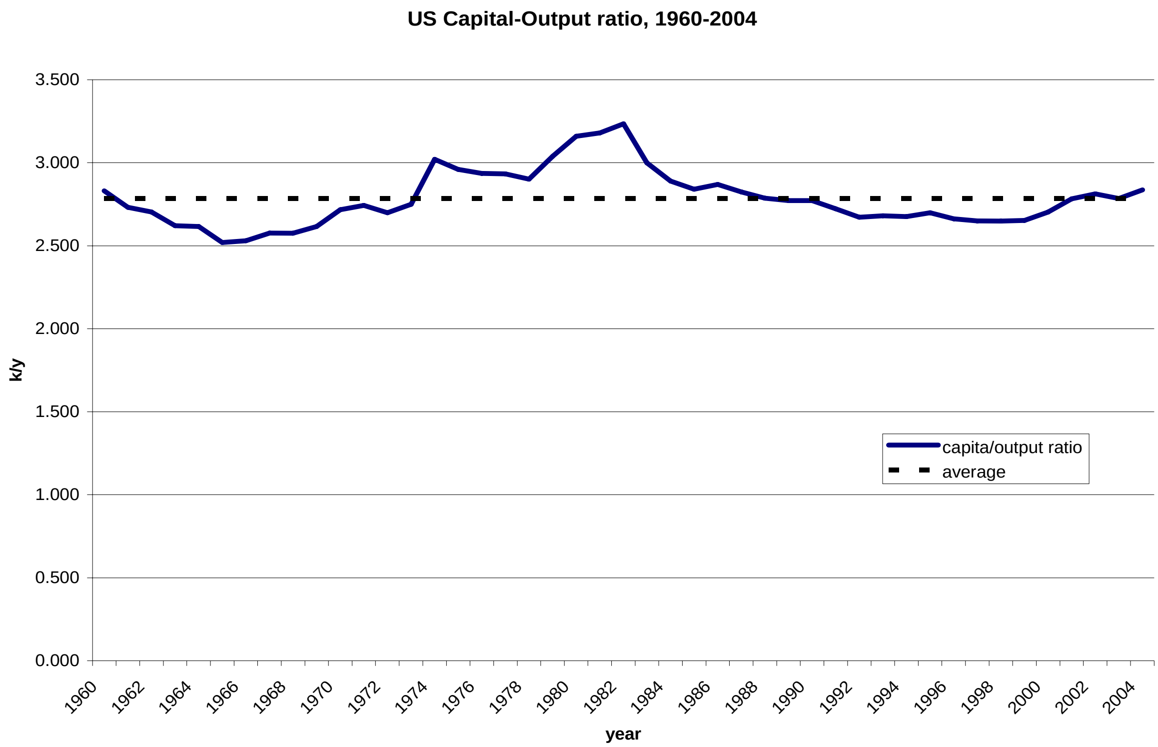

Figure 2
Immigration and Capital

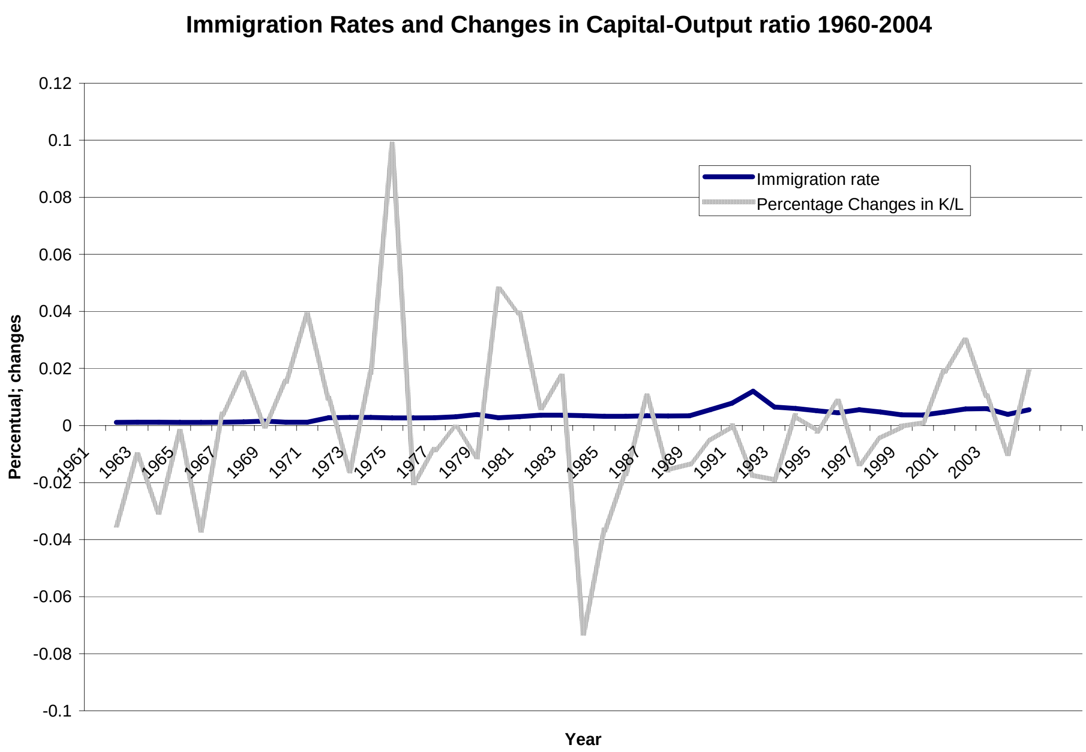

Figure 3
Immigration and Employment Growth, 1990-2004

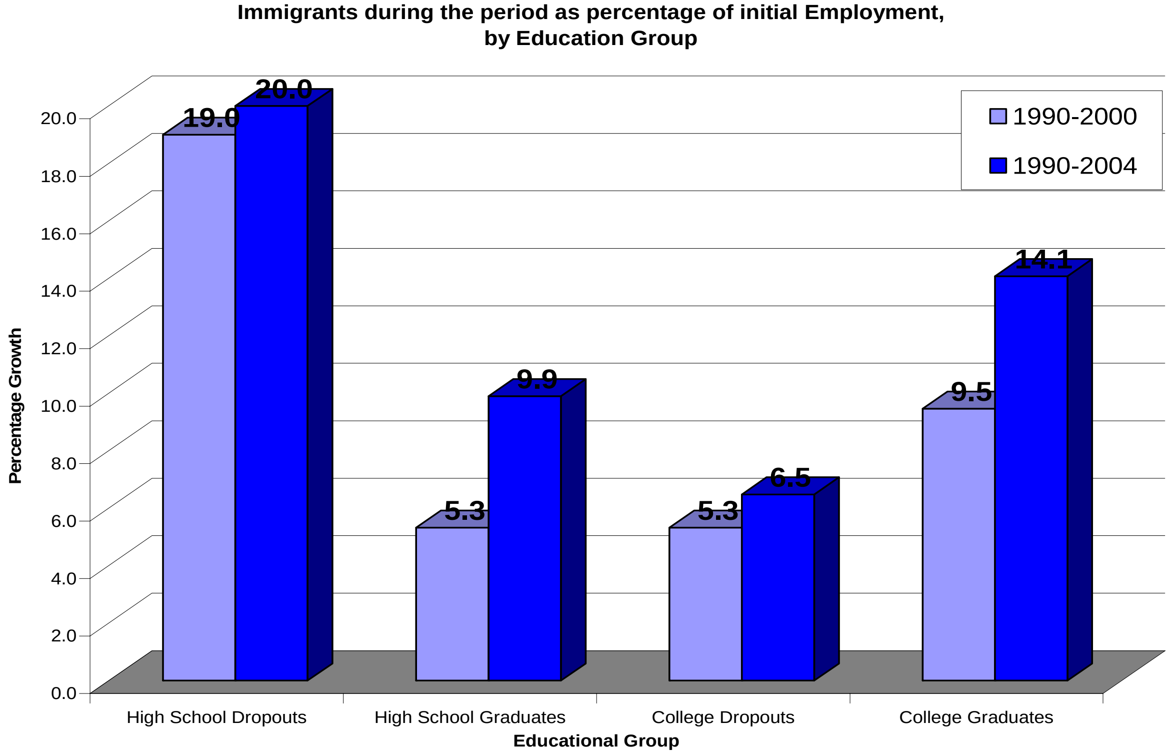

Figure 4
Growth of Real Yearly Wages of Us natives: 1990-2004.