



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

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Abstract

Recent influential empirical work has emphasized the negative impact of immigrants on the wages of US-born workers arguing, as a consequence, that immigration harms in particular less educated American workers and in general all US-born workers. As US and foreign born workers belong to different skill groups that are imperfectly substitutable one needs to articulate a production function that aggregates types of labor (and accounts for complementarity and substitution effects) in order to calculate the relative, absolute and average effects of the multi-skill labor immigration on US-born workers. We introduce such production function allowing (crucially) that US and foreign-born with the same education and experience can be imperfect substitutes and allowing endogenous capital accumulation. This function successfully accounts for the negative impact of the relative skill supply of immigrants on the relative wages of US workers. However, it generates, contrarily to the previous literature, a positive and large effect of immigration on average wages of US-born workers. We then show evidence of such positive effect by estimating the impact of immigration on average wages and value of housing across US metropolitan areas (1970-2000). We finally reproduce this positive effect by simulating the behavior of average wages and housing prices in an open city-economy with optimizing U.S.-born agents who respond to an inflow of foreign-born workers of the size and composition equal to the immigration of the 1990's.

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

JEL Codes: F22, J61, J31, R13

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1 Introduction

The U.S. has experienced for the last three decades a large surge in immigrant inflows. As figure 1 shows, the percentage of foreign-born residents of the United States has been steadily growing since 1970 and reached a value of 13% in 2003¹. Economists, demographers and social scientists have used models and empirical analysis in order to measure the impact of these immigrants on the U.S. economy and, in particular, on its US born residents. The National Research Council (1997) produced a 430 page volume analyzing the characteristics and effect of immigration on the US economy and society and, since then, a number of studies have re-examined and re-analyzed the issue. While the debate on several specific findings is still open, the recent analysis of the impact of foreign-born on natives seems to have focussed its attention on some issues and set aside others. Our paper wants to take a fresh look at the overall issue, emphasizing important connections between economic theory and empirical findings and providing a coherent frame to measure the impact of immigration on average productivity of US natives.

The question we tackle is: what is the impact of immigrants on the productivity and income of US born workers? This question has two parts. The first has a macro flavor: does the inflow of foreign born workers have a positive or negative net effect on the average production and income of U.S. born residents? This question supposes that we aggregate wages and income of heterogeneous U.S. born residents. The second question is more micro: how are gains and losses from immigration distributed across US born workers with different skills and between labor and physical capital? The consensus emerging from the recent literature is that the effect of immigrants on average (aggregate) income accruing to U.S. natives is rather small. Quantifications of this effect (such as Borjas, 1995) imply that the totality of foreign born workers accounts for a mere 0.1% increase in the average income (from labor and capital) accruing to U.S. born residents. Therefore, has been argued, one could neglect this small average effect and concentrate on the second question, namely the distributional effect of immigration. Moreover, as immigrants are normally endowed with little physical capital (not many of them bring their enterprise or house to the U.S.) most of the literature (e.g. Borjas 1995, 2003) has represented immigration as an increase in labor supply, assuming a constant stock of capital and has easily found (because of complementarity between the two factors) a negative impact of immigrants on average wages (and a positive impact on return to capital). The "macro" aspect of the issue (relating to average income and average wage income) has been analyzed much less and more simplistically, however, than the "micro" aspect. Most of the recent debate has been focussed on the effect of immigration on the relative wages of more and less educated US born workers. Some economists

¹While remarkable, such rapid increase is not unprecedented. Large migrations from Europe during the period 1880-1910 brought the percentage of foreign-born very close to 15% around 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.

have argued in favor of a large relative impact (Borjas 1999, 2003, Borjas Freeman and Katz 1997) and others in favor of a smaller, hardly significant, effect (Butcher and Card 1991, Card 2001, Lewis 2003). While the size and significance of the relative wage effect of immigration is still controversial, this paper intends to combine its analysis with the analysis of the average wage effect which has been considered settled (or unapproachable, or irrelevant) too easily. We nest the "macro" (average) and the "micro" (distributional) aspects of the problem within the same framework.

The effect of immigration on the average wage of US born individuals is extremely hard (if not impossible) to estimate directly with aggregate US data. The time series of the aggregate US data for wages and immigration after World War II contain only few dozens of observations and issues of omitted variables and endogeneity make the inference of causality from measured correlations a daunting task. The reported effects of migration on average wages found in the literature have been calculated (rather than estimated) using (very simple) aggregate production functions and imposing crucial restrictions on the substitutability of skills and the supply of factors (labor and capital). We will argue that the assumptions made so far, delivering a negligible effect of immigration on total income of US-born residents and a negative effect on average wages of US born workers, may not be the most appropriate. Dealing more carefully with issues of skill complementarities and physical capital accumulation we obtain positive effects of immigrants on average wages and income of natives. We analyze this crucial point by using estimation and simulation on aggregate data, as well as estimation and simulation on data from metropolitan areas.

The modern analysis of the effects of immigrants on wages of natives began with studies (Grossman 1982, Borjas 1987, Altonji and Card, 1991) that considered foreign-born as one homogeneous group of workers, imperfectly substitutable with US-born workers (possibly divided into sub-groups). A number of studies of relative supply of skills and relative wages of US born workers (such as Katz and Murphy 1992, Card and Lemieux 2001) make clear, however, that workers with different levels of schooling and experience are better analyzed as imperfectly substitutable factors. As a consequence, the analysis of the impact of immigrants on wages of US-born has been carried out, recently, considering workers partitioned among imperfectly substitutable groups (by education and experience) and assuming perfect substitution of native and foreign-born workers within each group (e.g. Card 2002 and Borjas 2003). Our paper uses a combination of the first and the second approach, in the sense that each of them can be seen as a special case nested in our more general framework. We assume the existence of an aggregate production function that combines workers and physical capital allowing education, experience and place of origin (US versus Foreign-born) to define groups that have imperfect substitutability with each other. Following Borjas (2003) we choose a Constant Elasticity of Substitution (CES) form and we nest two groups (US born and foreign born workers) within eight experience groups and those groups, in turn, into four educational attainment groups. This implies

that we assume workers with different levels of education and experience to be imperfectly substitutable and we also allow foreign born and US born in the same education-experience group to be imperfect substitutes. Such imperfect substitutability may be due to different training, different unobserved characteristics and different occupational choice between US and foreign-born. While there is a lot of anecdotal evidence (and reasons to believe) that a Chinese (born) cook is not a perfect substitute for an American cook and that an Italian tailor and a French architect are differentiated from their US counterparts, ultimately the degree of substitutability between foreign and US born will be estimated empirically. Finally in our production function we include physical capital and we treat its accumulation as endogenously driven by market forces that equalize real returns to capital in the long run². This is also a departure from the literature that mostly assumes fixed physical capital when evaluating the distributional effects of immigrants. Our production function can be used to calculate the relative, absolute and average wage effects of the recent inflow of immigrants as well as to simulate the effect of counter-factual scenarios.

In the first part of our paper we estimate the elasticity of substitution between foreign and US-born workers within education-experience cells using data from the US Censuses from 1970 to 2000. Adopting an empirical methodology similar to Borjas (2003) we find that the data support imperfect substitutability between the two groups. In particular, among college educated the elasticity of substitution between US and Foreign born is around four and among high-school dropouts it is around seven. That elasticity is higher (around 10) for the intermediate educational groups. Using these estimates and estimates available from the literature for the elasticity of substitution between experience groups (Card and Lemieux, 2001) and educational groups (Katz and Murphy, 1992) we can calculate the effect of immigration during the 1990's on relative wages or on absolute wages by education group or on average wages of US-born workers. For the preferred parameter choice, we calculate that the *average* wage of US born workers experienced an increase between 2% and 2.5% in response to the inflow of foreign-born workers in the 1990-2000 period (equal to 8% of the initial US labor force). At the same time, native workers without an high school degree experienced a real wage decrease by 1% while workers with an high-school degree or more gained as much as 3-4% of their wage, as effect of that inflow. We then compare the above elasticities (calculated using the CES production and structural parameters) with direct empirical estimates (original or taken from the literature) that use reduced-form regressions of US wages on immigration flows. We use national data to estimate the effects of relative immigration by skill-group on relative US wages (reproducing results in Borjas 2003) and Metropolitan-area data to estimate the absolute effect of immigration on wages of each educational group. These direct estimates match rather well the elasticities calculated using the CES production function for

²Constant real return to capital (in the long run) is an implication of classical growth models such as Solow (1956) or Ramsey (1928) as well as open economy macro models.

each education group.

As the positive and large effect of immigration on *average* US wages obtained from our CES-based calculations is novel in the literature and likely to be controversial we analyze it further. As mentioned above the average effect of immigration on marginal productivity of US born is impossible to isolate in the aggregate data. Hence, in the continuation of our empirical (and theoretical) analysis we concentrate on the panel variation across U.S. metropolitan areas over time and we exploit the differences in migration inflows and in growth of average wages of U.S. born residents. We first present evidence (and refer to previous work of ours such as Ottaviano and Peri, 2005; Ottaviano and Peri, forthcoming) that the average wage and the value of housing for U.S. born residents, were positively associated across metropolitan areas with inflows of foreign-born workers. A positive and significant effect survives 2SLS estimation using instruments which should be exogenous to city-specific unobservable productivity shocks that may bias OLS estimates. The instrument is obtained 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), such instrument is correlated with actual immigration in the metropolitan area if new immigrants tend to settle prevalently where country-fellows already live. On the other hand this "constructed" variable is independent of any city-shock and, in particular, totally orthogonal to any economic determinant of immigration into the city during the considered decades.

The empirical strategy of using cross-city variation in (relative) wages of native workers to estimate the impact of (relative) supply due to immigration has been widely used in the literature (Card 1990, Butcher and Card 1991, Card and Di Nardo 2000). However it has been widely criticized (Borjas, Freeman and Katz 1997) on the ground that US born workers would move across cities arbitraging away wage differences generated by differential immigration flows. While labor is not perfectly mobile certainly large real wages differentials will be arbitraged away in the long run given the high degree of mobility of US workers. To justify our empirical findings using metropolitan data and to further corroborate the positive effect of immigrants on the average wage of US-born workers we embed our original CES production function in a model that also includes consumption and housing decisions in an open city that assumes perfect mobility of US-born workers and firms into and out of the city. Due to the mechanisms of complementarity and endogenous capital accumulation (operating through the CES function) an inflow of foreign-born workers in a city increases the wage of the average US-born. In an open city this would tend to attract more US-born residents, however the increased number of people in the city and the increased wages would generate upward pressure on the price of housing (whose supply is constrained by land). The new equilibrium is reached when the local price index (driven by housing price) compensates for the nominal wage gains of US born workers. Average real wages for US-born workers are equated between the immigration city and the other cities after the

immigration shock. Therefore the equilibrium adjustment triggered by immigration at the city-level implies a positive average effect of immigrants on wages of US-born not eliminated by mobility because a large part of the adjustment takes place in the form of higher price of housing (that equalize real wages) rather than migration (that would equalize nominal wages). This model allows us to simulate the effect that an inflow of foreign-born has on the average wages and the average value of housing of American-born residents. Using an inflow of immigrants that simulates the experience of the average US metropolitan area in the 1990's (for magnitude and skill composition) we obtain effects on wages and value of housing very close to those estimated above using data from US metropolitan areas.

The remainder of the paper is organized as follows: in section 2 we introduce the aggregate CES production function and we use it to estimate the elasticities of substitution between US and foreign-born workers within each education group. Then, using structural parameters (from our estimates and from the literature) and the CES production function we calculate the impact of the 1990's inflow of immigrants on relative, absolute and average wages of US born workers. Section 3 presents direct estimates (ours and from the literature) of the impact of relative skills of immigrants on relative US wages using national US data and we compare them with the values obtained from the CES production function. We then concentrate on the effect of immigrants on average US wages. Empirically we move to a cross-city panel analysis exploiting the variation of immigrants inflows and wage changes across US cities 1970-2000. Both OLS and 2SLS estimates find a positive and significant effect of immigrants on average wages and value of houses of US-born. This effect is consistent with the positive aggregate effect of immigrant on wages of US-born calculated in 2. Section 4 provides a model of production-consumption-housing in an open-city economy that we can use to simulate the impact of the immigrants' inflow (during the 1990's) on wages and value of housing of US workers. Using plausible structural parameters the model matches very closely the quantitative effects estimated in the previous section 3. Section 5 concludes the paper.

2 Production, Complementarities and Gains from Migration

US natives and foreign born workers are differentiated into several imperfectly substitutable skill groups (classified by education and experience). Without assuming a production function we could only estimate directly some partial elasticities of substitution between groups. It would be impossible, however, to calculate the effect of a change in supply of foreign born belonging to several different skill groups on marginal productivity (wage) of natives in each of several skill groups. Following Borjas (2003), we choose a nested constant elasticity of substitution (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. We allow imperfect substitutability among groups in a structure that generates lower substitutability between groups of different schooling levels than between groups of different experience within the same schooling level. US-born and foreign-born are allowed a further degree of imperfect substitutability even when they have the same education and experience. The production function we use is the following:

$$Y = A\tilde{C}^\alpha K^{1-\alpha} \quad (1)$$

where Y is aggregate output, A is total factor productivity, K is physical Capital and \tilde{C} is a CES aggregate of several, imperfectly substitutable, types of workers. The production function described above exhibits constant returns to scale (CRS) in capital K and labor \tilde{C} . It describes production in the aggregate US economy. In this section we will use it to analyze the behavior of national wages of US-born residents in response to migration. However we can think of the nation as an aggregate of several cities with similar (CRS) production functions. In section 4 we use the same function (1) to represent production in the average US city. The Elasticity of output to the labor aggregate is α and \tilde{C} is defined as:

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

C_k is an aggregate measure of labour with educational level k and $\frac{1}{\tau_k}$ is the group-specific productivity. As standard in the labor literature (see Borjas 2003, Card and Lemieux 2001) we group educational achievements in four categories: High School Dropouts (denoted as HSD), High School Graduates (HSG), College Dropouts (COD) and College Graduates (COG), so that $k = HSD, HS, COD, COG$. The parameter δ measures the elasticity of substitution between workers with different educational achievements. Within each educational group we assume that workers with different experience are also imperfect substitutes. In particular following the specification used in Card and Lemieux (2001) we write:

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

where j is an index spanning intervals of five years-experience between 0 and 40 years, so that $j = 1$ captures workers with 0–5 years of experience, $j = 2$ those with 6–10 and so on. The parameter θ measures the elasticity of substitution between workers in the same education group with different experience levels. As we expect workers to be closer substitute within an education group than across them, our parameter choice (consistently with the findings of the literature) implies $\theta > \delta$. Finally, and differently from the recent

literature, we define $\frac{C_{kj}}{\tau_{kj}}$ as a CES aggregate of home-born and foreign-born workers with schooling k and experience j , (denoted, respectively, as H_{kj} and F_{kj}) in the following way:

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

Foreign-born workers may have received part of their education abroad, their language skills differ from those of natives, they often emphasize different qualities than natives and so on. Therefore they seem to be differentiated enough to be imperfect substitutes for US born workers even within the same education and experience group. Ultimately, will be the empirical analysis to reveal whether their elasticity of substitution with US born, in the same education-experience group, σ_k is finite (imperfect substitutes) or infinite (perfect substitutes). As indicated by the subscript k we allow the elasticity of substitution between US and Foreign born to differ across schooling groups (more on this below). The terms $1/\tau_{Fkj}$ and $1/\tau_{Hkj}$ measure the productivity levels of foreign workers and home-born workers.

As we use decennial data to evaluate the impact of immigration on US wages it is reasonable to treat physical capital as endogenously accumulated, rather than fixed. If we assume international capital mobility or, alternatively, accumulation of capital following the Ramsey (1928) or Solow (1956) model, then in the long run (balanced growth path) the real interest rate r as well as the capital-output ratio K/Y of the country will be constant. Given that the American economy has not exhibited any permanent trend in real interest rates and has exhibited a roughly constant capital-output ratio for the last century we are on safe empirical ground as well when making this assumption. As physical capital adjusts in order to maintain a constant interest rate (i.e. towards the BGP) we can solve K out of the production function and we get that output can be written as a linear function of the labor composite:

$$Y = \left(\frac{1-\alpha}{r} \right)^{\frac{1-\alpha}{\alpha}} A \tilde{C} = \hat{A} \tilde{C} \quad (5)$$

where $\hat{A} = \left(\frac{1-\alpha}{r} \right)^{\frac{1-\alpha}{\alpha}} A$ absorbs a constant into the TFP factor. Expression (5) shows that income per worker grows at the rate of exogenous technology, A (as in any neoclassical growth model) and therefore, in the long-run, the elasticity of income to the labor composite \tilde{C} is one. When calculating the long-run elasticities of wages to supply of any kind of workers we will use the production function in (5)³.

³This is one important difference with Borjas (2003) who, in calculating the long-run elasticities of wages to inflows of immigrants over twenty years, assumes a constant stock of capital.

2.1 Partial Wage Elasticities

Using the production function (5) and the definitions (2), (3) and (4) we can obtain the (natural logarithm of the) marginal productivity of US-born workers in group kj , that in a competitive market equals their (log) wage, w_{Hkj} :

$$\ln(w_{Hkj}) = \ln \tilde{A} + \frac{1}{\delta} \ln(\tilde{C}) + \ln \Phi_k - \left(\frac{1}{\delta} - \frac{1}{\theta} \right) \ln(C_k) + \ln \Phi_{kj} - \left(\frac{1}{\theta} - \frac{1}{\sigma_k} \right) \ln(C_{kj}) + \ln \Phi_{kjH} - \frac{1}{\sigma_k} \ln(H_k) \quad (6)$$

The term Φ_k contains all terms in τ_k , Φ_{kj} contains the term τ_{kj} and Φ_{kjH} contains τ_{kjH} . Expression (6) can be used to derive several wage elasticities, i.e. percentage variations of wages of US workers in response to percentage variations in supply of foreign-born workers keeping the efficiency terms fixed. The first elasticity considered is the percentage change in the wage of US-born workers of skill group kj in response to a percentage change of foreign-born workers in the same skill group kj keeping supply of other factors fixed. We call this elasticity γ_{wkj}^{own} , with the subscript indicating that we are focussing on the wage (w) of skill group kj of home-born workers and the superscript emphasizing the fact that we are changing the supply of foreign-born workers in the same skill group only. It is easy to show that this elasticity can be calculated as:

$$\gamma_{wkj}^{own} = \frac{\Delta w_{Hkj}/w_{Hkj}}{\Delta F_{kj}/L_{kj}} = \left[\frac{1}{\delta} + \left(\frac{1}{\theta} - \frac{1}{\delta} \right) \left(\frac{1}{s_k} \right) + \left(\frac{1}{\sigma_k} - \frac{1}{\theta} \right) \left(\frac{1}{s_{kj}} \right) \right] \frac{s_{Fkj}}{\varkappa_{Fkj}} \varkappa_{kj} \quad (7)$$

where we expressed, as customarily done in the empirical analysis, the (decennial) change in foreign-born ΔF_k as a percentage of the total initial supply of labor in skill group kj , L_{kj} , namely $\frac{\Delta F_{kj}}{L_{kj}} = (F_{kjt+10} - F_{kjt})/(F_{kjt} + H_{kjt})$. The variable s_{Fkj} is equal to the share of overall wages paid to foreign workers in skill group kj , $\frac{w_{Fkj}F_{kj}}{\sum_m \sum_i (w_{Fmi}F_{mi} + w_{Hmi}H_{mi})}$, and the variable \varkappa_{Fkj} equals $\frac{F_{kj}}{\sum_m \sum_i (F_{mi} + H_{mi})}$, the share of total employment represented by foreign-born workers in skill group kj . Analogously $\varkappa_{kj} = \frac{(F_{kj} + H_{kj})}{\sum_m \sum_i (F_{mi} + H_{mi})}$ denotes the share of total employment accounted for by workers (foreign and US born) in skill group kj . An interesting variation of the above partial elasticity can be calculated and compared with several existing estimates from the applied literature (see below). The elasticity of wage w_{Hkj} to a change in supply of F_{kj} keeping the total production and the intermediate labor composite, C_k fixed is given by:

$$\frac{\overline{\gamma_{wkj}^{own}}}{\gamma_{wkj}^{own}} = \left| \frac{\Delta w_{Hkj}/w_{Hkj}}{\Delta F_{kj}/L_{kj}} \right|_{C_k, \tilde{C} \text{ constant}} = \left(\frac{1}{\sigma_k} - \frac{1}{\theta} \right) \left(\frac{s_{Fkj}}{s_{kj}} \right) \left(\frac{\varkappa_{kj}}{\varkappa_{Fkj}} \right) \quad (8)$$

The elasticity in (8) is obtained from equation (6) by keeping the terms $\ln(\tilde{C})$ and $\ln(C_k)$ constant and computing only the partial variation of (log) wage w_{Hkj} in response to a variation in F_{kj} that operates

through the term $(\frac{1}{\theta} - \frac{1}{\sigma_k}) \ln(C_{kj})$. Its empirical equivalent is the elasticity obtained (for instance in Borjas, 2003), by regressing (log) wages of home-born workers on change in supply of foreign-born in the same education-experience group absorbing with time and education by time fixed effects the variation operating through the terms $\ln(\tilde{C})$ and $\ln(C_k)$. The elasticity $\overline{\gamma_{wkj}^{own}}$ has been considered as particularly interesting because, if US-born and foreigners within each skill group kj were perfect substitutes then $1/\tau_{Fkj} = 1/\tau_{Hkj}$ and $\frac{1}{\sigma_k} = 0$, implying that $(\frac{s_{Fkj}}{s_{kj}}) (\frac{\varkappa_{kj}}{\varkappa_{Fkj}}) = 1$ and the elasticity would simplify to $-\frac{1}{\theta}$ which is the inverse of the elasticity of substitution between two groups with different experience within an education group. While in that case $\overline{\gamma_{wkj}^{own}}$ would be equal to a "structural" parameter of the production function, under our more general assumption it is not. Moreover, imperfect substitutability between US born and foreign born workers implies that $\overline{\gamma_{wkj}^{own}}$ while generally still negative, will be smaller in absolute value than $\frac{1}{\theta}$.

A third interesting partial elasticity, also comparable with existing empirical estimates in Borjas (2003) (and partially with Card, 2001), is the wage elasticity for US born workers of skill kj to the total inflow of foreign-born within education level k (of any experience level) keeping total production constant. We define this elasticity as $\overline{\gamma_{wkj}^{own\ edu}}$ where the superscript indicates that we are only changing the supply of foreign born worker in the same education group k , the subscript refers to the wage (w) of skill group kj and the upper bar reminds us that total production is kept constant. Its expression is:

$$\overline{\gamma_{wkj}^{own\ edu}} = \left| \frac{\Delta w_{Hkj}/w_{Hkj}}{\Delta F_k/L_k} \right|_{\tilde{C}\ constant} = \left(\frac{1}{\sigma_k} - \frac{1}{\theta} \right) \left(\frac{1}{s_{kj}} \right) \left(\frac{s_{Fkj}}{\varkappa_{Fkj}} \right) \frac{\Delta F_{kj}}{L_k} + \left(\frac{1}{\theta} - \frac{1}{\delta} \right) \left(\frac{1}{s_k} \right) \sum_i \frac{s_{Fki}}{\varkappa_{Fki}} \frac{\Delta F_{ki}}{L_k} \quad (9)$$

The first term on the right hand side captures the effect on w_{Hkj} due to a change in supply of foreign-born in the same education-experience group, keeping C_k constant, the second term (a summation) captures the effect of changes in supply of foreign-born in each experience group within education k . Those effects operate through the change in the term $\ln(C_k)$ (see equation 6).

2.2 The Impact of Immigration on wages

While the partial elasticities γ_{wkj}^{own} and $\overline{\gamma_{wkj}^{own}}$, $\overline{\gamma_{wkj}^{own\ edu}}$ provide important information on the movement of wages of US born workers in each skill group in reaction to immigration specific to that group they do not tell us much about the total effect of immigration on wages of native workers. Total immigration has an effect on wages (of US born) that stems from "own" and "cross" elasticities. Presumably, in fact, due to complementarities, while the own elasticity effect on wage is likely negative the cross effects are likely positive. Using equation (6) we can define and calculate γ_{wkj}^{total} , the net percentage change in the wage of

US-born workers in skill group kj in response to the increase in the supply of foreigners in all skill groups, $j = 1, 2, \dots, 8$ and $k = 1, 2, \dots, 4$. This elasticity is equal to:

$$\gamma_{wkj}^{total} = \frac{\Delta w_{Hkj}/w_{Hkj}}{\Delta F/L} = \frac{\left(\frac{1}{\sigma_k} - \frac{1}{\theta}\right) \left(\frac{1}{s_{kj}}\right) \left(\frac{s_{Fkj}}{s_{Fkj}}\right) \frac{\Delta F_{kj}}{L} + \left(\frac{1}{\theta} - \frac{1}{\delta}\right) \left(\frac{1}{s_k}\right) \sum_i \frac{s_{Fki}}{s_{Fki}} \frac{\Delta F_{ki}}{L} + \frac{1}{\delta} \sum_m \sum_i \frac{s_{Fmi}}{s_{Fkm}} \frac{\Delta F_{mi}}{L}}{\Delta F/L} \quad (10)$$

where $\Delta F/L = \sum_m \sum_i \frac{\Delta F_{mi}}{L}$ where L is the total initial employment and the other variables are defined as above. In the numerator of (10) three terms are added. The last term (double summation) captures the positive effect from immigrants in all education and experience groups, due to complementarity with US born, the intermediate term captures the additional (negative) impact from immigrants in the same education group only (due to closer substitutability with home born in group kj) and the first term captures the additional (negative) impact from immigrants in the same education-experience group (even closer substitutes to home workers in group kj). Each term depends on combinations of the elasticities and on the size of immigration in each group ($\frac{\Delta F_{ki}}{L}$). Finally, aggregating the changes in wages of all US born workers in response to migration, and weighting them for the wage share of their skill-groups, we can obtain the elasticity of average wages of U.S. born workers to total change in supply due to immigrants. This elasticity, denoted as γ_w , measures, in percentage terms, the overall gain (if positive) or loss (if negative) accruing to US labor income as a consequence of immigration. Such elasticity is obtained as follows:

$$\gamma_w = \frac{\Delta \bar{w}_H/\bar{w}_H}{\Delta F/L} = \sum_k \sum_j s_{kj} \frac{\Delta w_{Hkj}/w_{Hkj}}{\Delta F/L} \quad (11)$$

2.3 Estimates of substitutability between US-born and Foreign-born

In order to calculate the partial elasticities γ_{wkj}^{own} , $\overline{\gamma_{wkj}^{own}}$ and $\gamma_{wkj}^{own\ edu}$ together with the total effects γ_{wkj}^{total} and γ_w only three sets of parameters are needed⁴: δ, θ, σ_k . The parameter δ is the elasticity of substitution between groups of workers with different education achievements. Several existing empirical studies estimated this parameter using micro data on US-native workers only or aggregate data⁵. Most of the existing estimates cluster between 1.5 and 2. The parameter θ has also been estimated in recent articles; notably Card and Lemieux (2001) produce estimates in the range between 3 and 4. We will use these values in our calculations. As for the parameters σ_k , ($k = HSD, HS, COD, COG$) because of the maintained assumption of perfect

⁴The shares of employment and total wage payments for each skill group are also needed.

⁵Katz and Murphy (1992), Angrist (1995), Ciccone and Peri (2005) are among recent works estimating this elasticity. Hamermesh (1992) Chapter 3 reviews the estimates in the previous literature.

substitutability between US and foreign born in the same skill group no previous work looked into estimating them. Our production function, however, provides a very simple frame to estimate these parameters. Taking the ratio of log wages of US and Foreign-born workers in the same skill group we obtain the following relation:

$$\ln(w_{Hkjt}/w_{Fkjt}) = -\frac{1}{\sigma_k} \ln(H_{kjt}/F_{kjt}) - \frac{\sigma_k - 1}{\sigma_k} \ln(\tau_{Hkjt}/\tau_{Fkjt}) \quad (12)$$

Equation (12) provides the basis to estimate the parameters σ_k . If we identify some variation of the relative employment of US and foreign born of skill kj in year t , H_{kjt}/F_{kjt} , that is driven by exogenous (supply) shifts and orthogonal to changes in relative productivity τ_{Hkjt}/τ_{Fkjt} we can use that variation as instrument in the 2SLS estimation of the coefficient $-\frac{1}{\sigma_k}$ in equation (12). In practice, following Borjas (2003) we assume that once we control for education by year (D_{kt}), experience by year, (D_{jt}) and experience by education (D_{kj}) fixed effects the inflow of foreign-born workers in a skill-group provides such exogenous shift in supply. The idea is that the distribution of a wave of immigrants across experiences groups within an education group is exogenous to US productivity shocks We therefore run the regression:

$$\ln(w_{Hkjt}/w_{Fkjt}) = D_{kj} + D_{kt} + D_{jt} - \frac{1}{\sigma_k} \ln(H_{kjt}/F_{kjt}) + \varepsilon_{kjt} \quad (13)$$

and use the variable $\ln(1/F_{kjt})$ as an instrument for $\ln(H_{kjt}/F_{kjt})$. We use country-level data from the IPUMS⁶ 1970, 1980, 1990 and 2000 and the division of groups based on education and experience described above. This generates 128 observations of skill by year relative wages and relative supplies. We pool all four schooling groups together, and we either assume equal elasticity across schooling groups $\sigma_k = \sigma$, or we allow a different σ_k for each group. The regressions produce estimates of $-1/\sigma_k$ and of their standard errors. We use the delta-method (e.g. Ruud 2000, page 367) to calculate σ_k and the relative standard error and we report them in the Table 1. First let me notice that in spite of the relatively large standard errors (due to few degrees of freedom as we control for 80 fixed effects) each estimated coefficient, $-1/\sigma_k$, (except for $-1/\sigma_{COD}$ from the second column of table 2) is significantly different from 0. This implies that foreign-born workers in a skill group are not perfect substitute for US-born workers, contrarily to what assumed by the literature. Second, while the average elasticity of substitution is 7.7, the estimates in column 2 show remarkably different elasticity in different skill groups. In particular within the group of college graduates foreign-born are hardest to substitute for U.S. born (elasticity of substitution around 4). Among the high-school dropouts foreigners are somewhat more substitutable for natives (elasticity of 7) while among the intermediate education groups

⁶Integrated Public Use Microdata Sample, Ruggles et al. (2005). For a detailed description of how we aggregate the individual data and how we control for personal characteristics see the Appendix .

(High school Graduates and College Dropouts) they are highly substitutable (elasticity between 10 and 16, very imprecisely estimated).

Are the above estimates reasonable? And why are similar US and foreign-born not perfectly substitutable (particularly among the highest and lowest educational groups)? When compared to the existing estimates of substitutability across experience groups within an education group, for US born (which range between 3 and 4 according to Card and Lemieux 2001) we find our estimates very reasonable. Native and foreign-born should not be much easier to substitute in production than two U.S. born workers with 5 years of experience difference. One reason for imperfect substitutability is that, for given skills, often US and foreign born workers choose different occupations (see Card 2001 for more detail). This is particularly true for high and low levels of education (rather than for intermediate levels) Among low skilled (HSD), for instance, foreign born are highly over-represented in professions like tailor (54% were foreign born in 2000) and plaster-stucco masons (44% were foreign-born in 2000) while US-born are over-represented, say, among crane operators (less than 1% was foreign-born in 2000) and sewer-pipe cleaners (less than 1% foreign-born). If those services are not perfect substitutes there is no reason to believe that their wages should be equalized. Among high skilled (COG) the same is true. For instance foreign-born workers are highly over-represented in scientific and technological fields (45% of medical scientists and 33% of computer engineers were foreign-born) while US-born are largely over-represented among lawyers (less than 4% are foreign-born) or museum curators and archivists (less than 3% are foreign-born) . Moreover even within the same profession often US and foreign-born provide different services and benefit from complementing each other. Among less educated, for instance, a Chinese cook and a US-born cook or an Italian tailor and a US-born tailor do not provide the same services. Similarly, among highly educated professionals a European-trained physicist (more inclined to a theoretical approach) is not perfectly substitutable with a US-trained one (more inclined to experimental approach) and a French architect provides different services than an American one. All in all, our empirical method produces (for high and low education groups) precise estimates, these estimates are in a reasonable range and anecdotal evidence suggests that US-born and foreign-born are not perfectly substitutable. We take, therefore, the above estimates seriously and use them in our calculations. One final remark. If immigration has an endogenous component that responds to relative productivity of skills, this would induce a positive correlation between the term τ_{Hkjt}/τ_{Fkjt} which is in the residual of regression (13) and the instrument $\ln(F_{kjt})$. This positive correlation would bias the estimates of $-\frac{1}{\sigma_k}$ towards 0 and, therefore, the value of σ_k will be biased up. In our calculations below, therefore, we consider the estimates of σ_k as a likely *upper bound* of the relevant elasticities and we experiment with smaller values .

2.4 Calculated Effects of Immigration on Wages and some Counterfactual Experiments

Table 2 shows the calculated effects of an increase in foreign-born workers on wages of US-born workers. The elasticities are obtained using formulas (8), (9), (10), (11) and data on wages and employment shares, relative to 1990, together with changes in supply of skills from the immigration of the 1990-2000 period are from the IPUMS of Ruggles *et al.* (2005). Column (a) reports the calculated partial elasticity of wage of US-born to an increase of immigrants in the same education-experience group, $\overline{\gamma_{wkj}^{own}}$, while column (b) reports the partial elasticity of US wages to immigrants in the same education group $\overline{\gamma_{wkj}^{own\ edu}}$. The total effect of immigration on the wage of US-born in each skill group, γ_{wkj}^{total} is shown in column (c) and the elasticity of the average wage of US-born to total immigration, γ_w , is reported in column (d). The last column, (e) reports the calculated percentage change in average wages of US-born as a consequence of the 1990-2000 inflow of immigrants. While we calculated $\overline{\gamma_{wkj}^{own}}$, $\overline{\gamma_{wkj}^{own\ edu}}$ and γ_{wkj}^{total} for each education-experience combination, in the table we only report the average by education groups (across experience groups). The first three rows of Table 2 show the calculated impact (for different parameter values) of the actual immigration shock of the 1990's. The shock, expressed as change of foreign-born in each skill-group relative to total initial (1990) employment was: $\Delta f_{HSD} = 1.9\%$, $\Delta f_{HSG} = 1.5\%$, $\Delta f_{COD} = 1.6\%$ $\Delta f_{COG} = 3.0\%$. While we choose 1.5 and 3 (respectively) as consensus values for the parameters δ and θ we show results for different choices of the parameters σ_k . The last three rows of the table, in contrast, present the effect of some counterfactual immigration flows.

Let us describe the results in turn. Specification 1, reported as way of comparison, assumes that US-born and foreign-born of the same skill group are perfect substitutes. Our estimates contradict this assumption that, however, is the standard one in the previous literature and is therefore useful as reference. Under this assumption the overall effect on average US wages of the 1990-2000 migratory inflow is very small (elasticity of 0.09) but positive. This result is in contrast with the findings of Borjas (2003) who found a strong negative effect of total immigration on average US wages (elasticity -0.3). Borjas' effect is entirely due to the assumption of fixed physical capital (rather than endogenously accumulated, as in our model) which seems extreme for a ten-year span. The small effect on average wages (i.e. on labor) is accompanied, however, by a strong redistributive effect. "Own" elasticities are negative and large: they average -0.3 for increased relative supply of foreign-workers in the same education-experience group and -0.62 for increased relative supply in the same education group overall. Therefore the relative size of immigrant groups across skills heavily affects the relative wage effects. Converting the elasticities γ_{wkj}^{total} into percentage effects of the immigration on US wages, the first row of Table 2 implies that real wages of high-school dropouts decreased

by 4.5%, the wages of workers with an high-school degree increased by 2% and the wages of college graduates did not change. These differences are due to the fact that immigrants are over-represented among low skills, proportionally represented among college graduates and under-represented among high-school graduates and college dropouts. Such U-shaped skill distribution of foreign-born generates the relative wage changes calculated in the first row.

Specification 2 calculates the effects of immigrants when we use the values of σ_k estimated in Table 2. We use values of seven and four (very close to the point estimates) as elasticity of substitution within the lowest and highest education groups, respectively, while within the two intermediate groups, exhibiting much less precise estimates of σ_k , we use a value of ten. The effects on average wage of US-born as well as the distributional effects change quite dramatically. First of all, the elasticity of average wages to immigration becomes positive and large. The 8% increase in foreign-born workers increase average US wages by 2.2%. Moreover now the three top education groups (HSG, COD and COG) all gain by a significant amounts (around +2.4% real wage increase in response to immigration) and only the low-skill group loses (2.4% wage decrease). Crucially, while the gains of the intermediate education groups are still driven by the relative supply of foreign-born (scarce in those groups) the gains of college educated stems from the lower degree of substitutability between US and Foreign-born in this group. Notice, however, that the own elasticities ($\overline{\gamma_{wkj}^{own}}$ and $\overline{\gamma_{wkj}^{own\ edu}}$) are still significantly negative for each group. Averaging across groups, $\overline{\gamma_{wkj}^{own}}$ is around -0.18 and $\overline{\gamma_{wkj}^{own\ edu}}$ is around -0.5 (more on this below). Finally specification 3 uses elasticity of substitution somewhat lower than the point estimate from table 1. This is done in order to account for a potential upward bias that may arise from endogeneity of skill-composition of immigrants. The chosen values are, however, within two standard deviations from the estimates of Table 1. As we can see the effect of immigration on average wages is even more dramatic. Now (converting elasticities in actual changes) the average wage of US born workers increases by 2.7% and the most dramatically affected group is that of US-born college graduates, whose wage increases by 3.5%! We define this specification as "preferred" for reasons that will be clear in the next section when we compare the calculated elasticities to those empirically estimated from the data in a reduced-form equation.

The last three specifications in Table 6 use our preferred parameter combination to evaluate the effects of some "counterfactual" migratory flows. Commenting briefly only the overall average effect on wages of US born few interesting indications emerge. First, if the US were to eliminate completely immigration of low skills (HSD) gaining an equal amount of immigrants among intermediate skills (HSG) so that total migration remained unchanged, such move would, slightly, decrease the overall beneficial effect of immigration on US average wages (increase by 2.6% rather than 2.7%). This effect is the result of relative scarcity of US-born high-school dropouts and higher substitutability of US and foreigners in the intermediate education groups.

Conversely (specification 5) eliminating the inflow of high-school graduate in favor of an equal increase in high-school dropouts, (making even more extreme the over-representation of foreign-born among low educated workers) would increase, slightly, the average marginal benefit to US wages (to 2.75%). Of course these two policies would have large impact on relative wages, with the second one exasperating the negative effect on wage of US low skills (decrease by over 8% as result of immigration). The most harmful scenario for average US wages, however, is the one reported in specification 6 in which the inflow of college graduates is eliminated in favor of an equal increase in college dropouts. In this case the effect of immigration goes from large and positive to substantially 0. Clearly the high complementarity of foreign-born in high-skill professions is a key element of the overall gains from migration generated in our model.

3 Empirical Estimates

3.1 Own skill-group Effects: Labor Demands are Downward Sloping

The calculations presented in Table 2 show very clearly that it is feasible, and in fact it is the case, that negative elasticities of wages to the supply of foreign workers in the same skill group, $\overline{\gamma_{wkj}^{own}}$ and $\overline{\gamma_{wkj}^{own\ edu}}$ coexist with positive overall average effect on US wages (γ_w) as well as with positive total effects for wages of US-born in some skill groups (γ_{wkj}^{total}). The elasticities $\overline{\gamma_{wkj}^{own}}$ and $\overline{\gamma_{wkj}^{own\ edu}}$ are measures of how the relative supply of foreign-skills affects the relative wage of US workers (with the same observable skills) keeping constant total production and the total intermediate labor composite. They are negative in most reasonably-specified production functions but cannot be used to evaluate the absolute effects of immigration on wages of US-born workers unless we embed them into a production function that accounts for substitution as well as complementarity effects. As mentioned above the empirical literature, that mostly dismisses the aggregate effect of migration as hardly relevant, has concentrated on the redistributive effect and, therefore, on the estimates of these elasticities. Typically the analysis of the effect of immigrants on relative US wages, considering the US as an integrated labor market segmented by skills, involves estimating a regression such as:

$$\Delta \ln w_{kjt} = \alpha_{kj} + \beta_{kt} + \beta_{jt} + (\overline{\gamma_{wkj}^{own}}) \Delta f_{kjt} + \varepsilon_{kjt} \quad (14)$$

In (14) the change of wages for US-born workers in skill group kj , $\Delta \ln w_{kjt}$, depends (once we account for education by time, experience by time, and experience by education effects) on the change in supply of workers in skill group kj caused by immigrants (Δf_{kjt}). This is, for instance, the regression run in Borjas

(2003) page 1363. We denoted the coefficient of Δf_{kjt} as $\overline{\gamma_{wkj}^{own}}$ because the above regression provides an estimate of the elasticity defined by expression (8). Alternatively, economists have used cross-city variation in the relative supply of foreign-born to identify the effect on the relative wages of US-born (e.g. Card, 2001). In that case, usually, the number of skill groups is reduced (to educational groups only) and an accompanying regression is run to check whether changes in relative employment of US-born workers compensate (and to what extent) the relative supply shifts due to immigration⁷. As these regressions use, more frequently, the relative change across educational groups they provide estimates for the parameter $\overline{\gamma_{wkj}^{own\ edu}}$.

The first column of Table 3 presents a sample of some recent influential estimates of the parameters $\overline{\gamma_{wkj}^{own}}$ and $\overline{\gamma_{wkj}^{own\ edu}}$ together with our estimates of those coefficients. The second column of the table shows, as way of comparison, the calculated values for those elasticities using expressions (8) and (9). The first row of Table 3 shows the estimate of $\overline{\gamma_{wkj}^{own}}$ from Borjas (2003), the second row reports the estimate we obtain when we replicate Borjas' regression, using a slightly different sample (1970-2000) and a different definition of wage (hourly rather than weekly). Our estimate is somewhat smaller in absolute value (-0.15 vs. -0.29) and more precise than Borjas', but within two standard deviations from his. Both coefficients are estimated using national data in a regression as (14) assuming as exogenous the distribution across skill groups of immigrants. Our point estimate is right in the middle of the range for the elasticity $\overline{\gamma_{wkj}^{own}}$ obtained using the calculation of the previous section (between -0.13 and -0.18 choosing specification 2 and 3 of Table 2). Borjas' estimate is outside that range but, because of a large standard error, it cannot reject a value in that range either.

Specification 3 of Table 3 reports the range of wage elasticities to immigrants of the "own" skill group taken from Card (2001). Such elasticity is smaller but not far from those estimated in the previous two rows. Card's estimate cannot, however, be directly compared with the two previous estimates. First, the skill groups chosen by Card are not education-experience based but occupation-based. Workers are grouped in 6 skill categories, each one defined by a probability of being in a group of occupations and our production function would not have a clear prediction on the estimated elasticity. Second, Card (2001) uses only data from 1990 Census (for 175 metropolitan areas) and by experimenting with our data-set we found the estimates rather sensitive to the specified sample. While we think that the choice of skill groups and samples may matter we do not believe that the two common criticisms (proposed by Borjas among others) to city-based elasticity estimates apply here. The first criticism is that internal migration of US-born workers would arbitrage wage differences away. This mechanism, however, would entail a significant association between

⁷Typically a supplemental regression such as $\Delta n_{ckt} = \alpha_{ck} + \beta_{ct} + (\gamma_{E_k})\Delta f_{ckt} + \varepsilon_{ckt}^E$ is run. Δn_{ckt} is the change in employment of US-born of skill k in city c . Once we account for city-by-year fixed effects and city-by-skill fixed effects, γ_{E_k} captures the impact of an inflow of foreign-born on the employment of US-born within a skill group in a city.

outflows of US-born workers from a city and the inflow of foreign-born. The most careful studies of the response of US-born to immigration (e.g. Butcher and Card 1991, Card and Di Nardo 1998, Card 2001) seem to show, to the contrary, that an inflow of US-born is associated with higher immigration in cities⁸. Moreover in our model of section 4 we show an alternative mechanism that establishes equilibrium across cities following an inflow of foreign-born and allowing mobility of US-born. That mechanism does not imply wage equalization, as long as there can be changes of city-level prices (value of housing). The second criticism is that immigration in cities is correlated with city-specific productivity shocks inducing a correlation between explanatory variables and residuals that biases the estimated elasticity. To address this issue Card (2001) constructs reasonable instruments. In order to produce estimates that are less likely to suffer from omitted variable bias Card considers the initial share (in year 1985) of foreign-born workers in each metropolitan area, using 17 nationality-groups of origin. For each nationality-group he calculates the share of workers in each skill-group. He then impute to each nation-of-origin-by-skill group in each metropolitan area, the overall immigration rate for that group into the US. Aggregating across national groups in each city this procedure produces a "constructed" increase in the number of foreign-born workers in each skill group in each city. The constructed values are good predictors for the actual ones if, as argued by Card (2001), new immigrants settle, at least for a period, where country fellows already live. Importantly, as the instrument only uses initial composition of foreign-born residents in a city and subsequent average immigration rates in the US by nationality it is not correlated, by construction, with any city-specific factor that would affect actual immigration in the city during a decade. As a consequence it is orthogonal, by construction, to any city-specific shock to productivity, amenities and labor market conditions.

Row 4 of Table 3 shows the estimates of $\overline{\gamma_{wkj}^{own\ edu}}$ from Borjas (2003). As national data are used (5 census years and only 4 education groups) the reported elasticity is estimated on 20 observations only and it is therefore very imprecise. What makes it, however, appealing is that it is not far from existing estimates of the relative wage elasticity to changes in relative supply of workers in different educational group (Johnson 1970, Fallon and Layard 1975, Katz and Murply 1992, Angrist 1995, Ciccone and Peri 2005) that range between 0.5 and 0.76. The standard error, however, is so large that not even $\overline{\gamma_{wkj}^{own\ edu}} = 0$ can be rejected. To improve on the precision of these estimates our procedure (row 5) relies on cross-city regressions and uses instruments built similarly to those in Card (2001) described above⁹. We regress change in wages of US-born workers in the usual four education groups across 86 US cities over 3 decades on changes in employment due to inflow of immigrants. We control for city by time and education by time fixed effects and we instrument the supply of foreign-born workers using the "constructed" supply. We obtain a point estimate of -0.45 with

⁸There are some early estimates (notably Filer 1992 and Frey 1995) that report native outflows associated to immigrants inflows in cities. They are however based on restricted samples and less careful empirical strategy.

⁹Details on the construction of this instrumental variable are in the Appendix 6.

a standard error of 0.25, reported in specification 5 of table 3. Again our estimate is within two standard deviations of Borjas' moreover it is exactly in the range calculate for $\overline{\gamma_{wkj}^{own\ edu}}$ in Table 2 (between -0.50 and -0.45 using specification 2 and 3). Moreover, both estimates of specification 4 and 5 are or close to the existing range of estimates for the elasticity of relative wages to relative supply of workers in different education groups, found in the literature (see Ciccone and Peri 2005 for a survey of those estimates).

3.2 Total Effects of immigration on wages of different Skill Groups

Comforted by the remarkably good match between our calculated "own-skill group" elasticities and those estimated in a "reduced-form" approach by the literature, we proceed to compare the calculated effects of Table 2 with direct estimates of the overall effect of immigration on the absolute wage of each skill group, namely the elasticity γ_{wkj}^{total} . As we showed above these overall effects depend on a negative "own-skill-group" effects as well as on positive (complementarity) effects from changes in supply of other skills. Empirically, we can run the following four regression:

$$\Delta \ln \bar{w}_{ckt} = \alpha_c + \beta_t + \gamma_{wk}^{total} \Delta f_{ct} + \varepsilon_{ct}, \text{ for } k = HSD, HSG, COD, COG \quad (15)$$

where \bar{w}_{ckt} is the wage of U.S. born workers in education group k , for city c and period t while Δf_{ct} is the *total* number of foreign-born workers (relative to initial employment) in city c and period t . The existing empirical literature has been hesitant in performing an estimation such as (15) because it is clear that the coefficient γ_{wk}^{total} is not a structural parameter and may vary with the skill-composition of foreign-born. In our case, however, we have a prediction of what γ_{wk}^{total} should be, given the observed distribution of US-born and immigrant workers by skill (1990-2000). Using the constructed share of foreign-born described in appendix 6 as instrument and controlling for city and year fixed effects we can obtain unbiased estimates of γ_{wk}^{total} for each education group. The estimates, reported in Table 4, capture the average (cross cities) effect of a 1% increase in the total supply of foreign-born on wages of US born in each group. This elasticity captures directly the effects calculated in column (c) of Table 2. Specification I reports the estimated coefficients using a panel of 86 cities for the censuses between 1970 and 2000. Column II shows the estimates using 113 cities over the censuses 1970-1990¹⁰. Column III reports the range of calculated elasticity from Table 2, column (c), specification 2 and 3. Each coefficient (cell) in column I and II of Table 4 is estimated in a separate regression. While the estimates are not very precise, the values of the elasticities are similar for each sample. Moreover the estimated coefficients are consistent with those calculated using the CES function. The impact on high-school dropouts is estimated between -0.10 and -0.20. The corresponding

¹⁰The reduced number of cities for the longer panel is due to the limited availability of the MSA identifier in the IPUMS 2000.

value, calculated using the CES and reported in column III, is -0.30. The impact on high school graduates as well as college dropouts is estimates around 0.2 and the corresponding calculated elasticities are between 0.28 and 0.33. The effect on college graduates is the only one significantly positive and estimated around 0.40 while the corresponding calculated parameter is between 0.33 and 0.44. Again, given the simplification involved in the reduced-form estimation it is remarkable that the coefficients match up so closely with those calculated using our production function. Two remarks are in place. First the positive and significant effect of immigration on US-born college-graduates is, by itself, a sign that in this group complementarities must be strong. In presence of perfect substitutability and due to relative scarcity alone, in fact, we should expect an effect on college graduate wages close to zero (as in Table 2, first row). Second, by focussing on total effects by skill group, it is already clear that an inflow of foreign-born has mostly positive effects on wages of US born. Recall, in particular, that the three groups that benefit from immigration (*HSG*, *COD* and *COG*) account in total for 92% of the US-born labor force in 2000. The losses from migration are concentrated on a very small group which, moreover, has been dramatically shrinking, among US-born in the last 30 years.

3.3 Average Effects of immigration across cities: Wages, Value of Housing and Employment

The previous two sections show that relative and absolute effects of immigration on wages of natives obtained using the CES production function match rather well the estimates from reduced-form regressions. The most striking and potentially controversial finding of Table 2 is, however, the large positive overall gain for US-born labor (as found by Borjas 1995, 1997, 1999, 2003). As this aggregate effect is impossible to detect in the national aggregate data we aim at measuring it by using cross-city variation. We intend to provide not only empirical evidence in favor of such positive aggregate effect but also a detailed account of how such effect is produced and maintained in a long-run equilibrium. Hence we accompany the wage regressions with regressions of cross-city value of housing and change in employment: as we will show in section 4 a simple general equilibrium model should account for the behavior of wages, rents and employment of US-born in an open city in response to immigration.

In previous work (Ottaviano and Peri, 2005; Ottaviano and Peri forthcoming) we detected a positive and very robust relationship between average wages of US-born and share of foreign-born across US-cities. In those articles we analyzed separately the wage-rent equilibrium (Ottaviano and Peri, 2005) and the wage-employment equilibrium (Ottaviano and Peri, forthcoming) concluding that the simultaneous positive effect of immigration on all the variables analyzed, relative to US-born workers, was only compatible with a positive effect of foreign-born on the productivity of US-born. We illustrated in section (2) how the overall positive

effect on US-born emerges from the combination of complementarities of Foreign-born across skills. Here we reproduce some of the wage-employment-rents estimates across cities that confirm the positive effect of immigrants on each variable and in the next section we match quantitatively these estimates with a simple general equilibrium open-city model that incorporates the production function developed above.

Figures 2, 3 and 4 illustrate the correlation between the change in foreign-born workers (in percentage of the total initial employment) and the percentage increase of average wages of US-born workers (Figure 1), or the percentage increase of the average rent per room paid by US-born residents (Figure 2) or the percentage increase of the employment of US-born (Figure 3) across the 86 largest metropolitan areas in the United States for the 1970-2000 period . The visual impression suggests a positive and strong correlation of the share of foreign-born with each of the three variables. Metropolitan areas where foreign-born workers came in larger numbers experienced faster growth of average wages for US-born workers, they exhibited faster growth of employment for US born workers, as well as faster growth of property values (captured here by higher rents) for their homes. Without implying a direction of causality, yet, the described statistics show that an increase in foreign born is associated with all the characteristics of a booming metropolitan economy. In the remaining of this section we analyze more formally these positive correlations in order to understand whether they are likely to be spurious or due to omitted variables.

Using the Integrated Public Use Microdata Samples of the US census 1970, 80, 90 and 2000 for individuals in 86 metropolitan areas¹¹ we estimate the following three panel regressions:

$$\Delta n_{ct} = \alpha_c + \beta_t + \gamma_E \Delta f_{ct} + \varepsilon_{ct}^E \quad (16)$$

$$\Delta \ln \bar{w}_{ct} = \alpha_c + \beta_t + \gamma_w \Delta f_{ct} + \varepsilon_{ct}^w \quad (17)$$

$$\Delta \ln \bar{r}_{ct} = \alpha_c + \beta_t + \gamma_r \Delta f_{ct} + \varepsilon_{ct}^r \quad (18)$$

Each of the regressions (16)-(18) considers as explanatory variable Δf_{ct} , the percentage increase of the total employment of city c in decade t due to immigration defined as percentage change in employment due to foreign-born (15). If such increase, once we control for city fixed effects, α_c , and period fixed effects, β_t is exogenous to economic conditions of city c , then regression (16) estimates the effect of this increase on the increase of employment of US-born workers in city c and decade t , as percentage of total initial employment, namely, $\Delta n_{ct} = (H_{ct+10} - H_{ct}) / (F_{ct} + H_{ct})$. The coefficient γ_E captures the elasticity of

¹¹Details on data and on the construction of variables are reported in the Appendix 6.

US-born employment to an increase of foreign-born workers. The coefficient γ_w in regression (17) quantifies the percentage increase of the average real wage (in 2000 constant dollars) of US-born workers in city c and decade t to an increase of foreign-born workers¹². Finally coefficient γ_r in regression (18) quantifies the percentage increase of the real average house value (in 2000 constant dollars) of US-born workers in city c and decade t in response to an increase of foreign-born workers, equal to 1% of total employment¹³. Due to city-specific productivity shocks the variables ε_{ct}^E , ε_{ct}^w and ε_{ct}^r are likely correlated with migration flows Δf_{ct} . We can, however, use as instrument the usual constructed shares of foreign-born based on the Card (2001) method and described in appendix 6. That instrument is an excellent one in these regressions. The partial R^2 of the first stage regression is 0.25 and the F-test for excluding the instrument is above 100 for each regression. Table 5 reports the 2SLS estimates of the coefficients $\gamma_E, \gamma_w, \gamma_r$. Column I reports those obtained with the panel of 86 cities over 4 census years and column II reports those based on 117 cities and 3 census years. Before commenting the coefficients in detail let us make two general remarks. First the OLS estimates (not reported, available from the authors) are not far from the 2SLS ones. They are, however, somewhat larger implying the potential existence of an upward OLS bias. Second we did not include any control (besides city and time fixed affects) in the regression to avoid endogeneity of regressor that we cannot solve with an IV strategy. Our previous work (Ottaviano and Peri 2005, forthcoming) introduced a series of controls and checks. The interested reader may check that the estimated positive coefficients are rather robust to most controls.

The first row of table 5 shows the estimated impact of immigrants on employment of US-born, γ_E . That effect is very imprecisely estimated but positive. No evidence exists of increased aggregate emigration of US-born workers from cities that attract larger number of immigrants. The impact of immigration on wages (row 2 and 3) and on the value of housing (row 4 and 5) of US-born residents is significantly positive. We used alternatively yearly or hourly wages of US-born workers (rows 2 and 3) and controlled in a first-stage regression for individual characteristics. The estimates in row 2 and 3 imply that an increase in foreign-born workers by 1% of the total employment raises between the average wage of U.S. workers by 0.35 to 0.46 percentage points. The last two rows calculate the impact of foreign-born on the value of housing of US-born residents. We used, alternatively, gross rent (for leased properties) and value of housing (for owner-occupied ones) as measures of the value of housing. The estimated coefficients imply that an increase of foreign-born by 1% of initial employment caused an increase in the value/price of housing for US-born by 1.1 to 1.6

¹²In order to control for city composition, the value $\ln \bar{w}_{ct}$ is calculated as the city-specific intercept of a mincerian regression of log hourly (or yearly) wage of US born workers (in constant 2000 prices) on personal characteristics (years of schooling, experience dummies, gender dummy, race dummies, marital status dummy). The regressions are run separately for each census year. Details are reported in Appendix 6.

¹³The value $\ln \bar{r}_{ct}$ is calculated as the average value of houses occupied by US born people (in constant 2000 prices) divided by the number of rooms in city c and year t . Alternatively The gross rental value per room is used as measure of housing value. Details are in the Appendix 6

percentage points. These estimates seem to imply a strong positive impact of foreign-born workers on city economies, that put upward pressure on wages, housing price and attracted (or in any case did not push away) native workers. Remarkably the average effect of immigrants on US wages (mostly between 0.35 and 0.38) is very close to the effect of immigrants on average wages calculated in Table 2, row 3, and equal to 0.34. Our production-function seem to match well the aggregate effect on wages when we estimate it on the cross-city variation. In the next section we account also for the observed elasticities of housing prices and of internal migration.

4 An Open City Model

4.1 Description of the Model

To simulate the reactions of US-born wages, rents and location decisions to foreign immigration, we embed the aggregate production function (1) in a simple model of a small city within an open city system. Specifically, consider a city with land area equal to T inhabited by L workers. To reduce the complexity of the extended set-up, we neglect differences in experience across workers and focus instead on differences in education only. Accordingly, workers are differentiated in four education groups (HSD, HSG, COD, COG) as well as between home and foreign born (H and F). This gives rise to eight groups, whose supply are denoted as in the following matrix:

Skill	Home	Foreign	Total
HSD	H_{HSD}	F_{HSD}	L_{HSD}
HSG	H_{HSG}	F_{HSG}	L_{HSG}
COD	H_{COD}	F_{COD}	L_{COD}
COG	H_{COG}	F_{COG}	L_{COG}
Total	H	F	L

All workers share the same preferences that are defined over three goods: the freely tradable good Y , non-tradable services X , and housing Z . The corresponding utility function is:

$$U = Y^\alpha X^\beta Z^{1-\alpha-\beta} \quad (19)$$

with

$$X = \left[\left(\frac{X_H}{\tau_{XH}} \right)^{\frac{\gamma-1}{\gamma}} + \left(\frac{X_F}{\tau_{XF}} \right)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}} \quad (20)$$

where Y is the consumption of the tradable good and Z is the consumption of housing. Services come in two

varieties that are horizontally differentiated in terms of “ethnicity” with elasticity of substitution equal to $\gamma > 1$. The idea we want to capture is that the ethnic diversity of local services may add to urban amenities. Accordingly, X_H and X_F label consumptions of home and foreign varieties respectively. Subutility (20) exhibits ‘love of variety’: workers prefer a balanced consumption of both ethnic varieties.

Home-born workers are freely mobile among cities¹⁴. They consume and supply their labour in the city where they reside. This requires cities to be sufficiently far apart to prevent commuting. Each worker inelastically supplies one unit of labor to the production of tradable good Y and one unit of labor to the production of her own ethnic variety of non-tradable services X (‘backyard production’). All markets are perfectly competitive. The production of the tradable good Y is identical to the one defined in (5) with the only simplification that within the labor composite defined in (2) we do not subdivide each education group in experience cells (we let θ of expression 3 be ∞). Housing production requires one unit of land per unit of output. Lot size is normalized to unity so that in the city housing supply equals T . The production of variety h of non-tradable services X requires one unit of labor of type h per unit of output. Hence, $X_H = H$ and $X_F = F$. What we have in mind is the fact that in a city with more foreign-born residents there will be a richer diversity of restaurants, specialty food shops and entertainment opportunities that may enhance the utility of local residents as long as foreign- and US-born services are perceived as differentiated. For example, Chinese, Italian, Brazilian restaurants as well as Spanish opera singers, Russian dancers and Ukrainian ice skaters provide specific services that are not identical to those of US-born competitors. Thus, home and foreign born may complement each other in terms not only of tradable production (see 5) but also of non-tradable consumption (see (19) and (20)). Finally, we call $1/\tau_{Xh}$ the efficiency units of a worker born in h in the production of her group-specific services X_h ($1/\tau_{Xh}$ can be also interpreted as a quality parameter).

In equilibrium workers maximize utility, firms maximize profits and all markets clear. Since US-born workers are free to move across cities, workers within the same skill group reach the same level of utility everywhere. Similarly, since firms are free to enter and exit, their profits will be equal to zero everywhere. As the formal equilibrium conditions are fairly standard, we prefer to relegate them and their derivation to Appendix 7 to focus instead on the logic of our simulation experiment.

4.2 Parametrization and Calibration

Our city is a small-open economy in which US-born workers move in and out in order to equate their indirect utility (‘real wage’) in the city to the real wage perceived in the rest of the economy. We want to calibrate this city as the average US city in order to simulate the effects of foreign immigration from 1990 to 2000 on the

¹⁴We assume as exogenously given the distribution of Foreign-born and a change in their supply is an immigration shock.

average wages, rents and location decisions of US born workers. In so doing, we compare that city equilibrium before and after the migratory shock captured by the change of the supply of foreign-born workers in each of the four education groups (ΔF_{HSD} , ΔF_{HSG} , ΔF_{COD} , ΔF_{COG}). We model such shock as exogenous to any city-specific event. Variables with a 0 subscript are associated with the pre-shock equilibrium (1990), while a subscript of 1 denotes post-shock values (2000). Our exercise is, therefore, one of comparative statics as we consider what happens to the variables of interest once the new equilibrium is reached. However, in order to understand the mechanisms that drive the migration of workers between the shock and the new equilibrium, we also report the “effect on impact” of the immigration of foreign-born, that is, what happens to wages and the values of houses before the migratory response of US citizens takes place.

The initial equilibrium is calibrated on the average US metropolitan area in 1990. We standardize its initial total employment as well as its land endowment to 1. Accordingly, the vector of the initial endowments of US-born workers (H_{HSD0} , H_{HSG0} , H_{COD0} , H_{COG0}) is (0.084, 0.257, 0.294, 0.264) while the vector of the initial endowments of foreign-born workers (F_{HSD0} , F_{HSG0} , F_{COD0} , F_{COG0}) is (0.031, 0.02, 0.024, 0.029). This implies that foreign-born workers as a whole equal 10.6% of US employment, which corresponds to the aggregate figure for metropolitan areas in year 1990. Their distribution was unequal across skill groups as they were over-represented among low-skilled (26% of high-school dropouts), under-represented among medium-skills (7.5% of high school graduates and college dropouts) and about exactly represented among high-skills (10% of college graduates).

The magnitude of the immigration shock during the 1990’s is certainly large, as the foreign-born population almost doubled in the US, going from 7% to 13.5% of total employment. Our experiment maintains the employment and distribution of US-born workers as in 1990 and increases foreign-born workers by the amount experienced by the average US metropolitan area during the 1990-2000 period. The resulting shock is $(\Delta F_{HSD}, \Delta F_{HSG}, \Delta F_{COD}, \Delta F_{COG}) = (1.9\%, 1.5\%, 1.5\%, 3.0\%)$. The total increase in foreign employment is, therefore, 8% of initial US employment. Notice that the values used for the initial conditions and for the shock are exactly the same as those used in the calculations in Section ??.

We obtain some of the parameter values required to simulate the model directly from the literature or from simple calculations. Others are, instead, estimated. We also provide several robustness checks of our simulation results using different values of the parameters. The parameters of the utility function have been obtained using the share of expenditures of households on housing services to obtain $(1 - \alpha - \beta)$ and on local food and entertainment services X to obtain β . These data are from the Consumer Expenditure Survey, available at Bureau of Labor Statistics (2005). The share of expenditure in housing services for the 1999-2002 period was somewhat larger than 0.20. We choose $1 - \alpha - \beta = 0.20$ as base-value and we also test the effect of $1 - \alpha - \beta = 0.25$. As for the share of expenditure on local service X , we include the expenditures for food

in restaurants, food in specialty shops, and entertainment. This share ranges between 0.15 and 0.20 of the expenditure of the average US household. We choose $\beta = 0.2$ as base-value and test the effect of $\beta = 0.15$. As for the substitutability between the non-tradable services provided by US-born and foreign-born, we are very conservative assuming a high elasticity (6–7). Considering that, as estimated by Weinstein and Broda (2004), the median elasticity of substitution between goods within a five-digit SITC sector is 4.7, our values are certainly on the high side.¹⁵ Such choice of high elasticity limits the importance of ethnic diversity in making a location attractive, therefore biasing the results against us.

In the production function of the traded good (??) we assume an elasticity between skill groups $\delta = 1.8$ (and then we experiment with 2), which is consistent with our choice in Section 2. The relative efficiencies of the factors ($1/\tau_k$) are chosen to match the national wage premia between education groups given their relative supply and the elasticity of substitution δ . Standardizing the efficiency of *HSD* workers, $\tau_{HSD} = 1$, we can obtain the other values by using the formula $\ln\left(\frac{\tau_{HSD}}{\tau_k}\right) = \frac{\delta}{\delta-1} \left[\ln\left(\frac{w_k}{w_{HSD}}\right) + \frac{1}{\delta} \ln\left(\frac{E_k}{E_{HSD}}\right) \right]$, where w_k is the national average wage for workers of education k and E_k is the total supply of workers of education group k . The relative efficiency of foreign-born to US-born in any skill group as well as in the production of the local service has been set equal to 1.

After the (exogenous) immigration shock the new equilibrium is established when the supply of US-born workers in the city is adjusted so that the utility they enjoy in the city is the same they would enjoy anywhere else. Under the small economy assumption, US-born utility levels elsewhere are kept constant at their initial values ($\bar{V}_{HSD}, \bar{V}_{HSG}, \bar{V}_{COD}, \bar{V}_{COG}$). These are, of course, unobservable and are calculated as the implicit values that make the US born equilibrium supply predicted by the model match their actual supply in 1990 ($H_{HSD0}, H_{HSG0}, H_{COD0}, H_{COG0}$) for the given initial distribution of foreign-born residents ($F_{HSD0}, F_{HSG0}, F_{COD0}, F_{COG0}$)¹⁶. This completes the parametrization of the model. In the following section we describe the results of its simulation.

4.3 Simulation Results

Table 6 summarizes the results of our simulations. Maintaining the common average shock that mimics the increase in foreign-born experienced during the 1990’s, the seven columns correspond to simulations for different combinations of parameter values. While we are mainly interested in the long-run (equilibrium) effect in order to match our estimated effects across decades, the first two rows (below the parameters values) report the effects on impact (short-run) of immigrants on average wages and values of housing of US-born workers. The following three rows report the effect on the average variables for US-born individuals (i.e., the

¹⁵For instance a narrow SITC-5 digits category such as “cheese” has an elasticity of 4.5 among its varieties.

¹⁶See appendix 7 for details on the calibration of the initial utility levels.

percentage change in average wage, the percentage change in the value of housing, and the migration in or out) all calculated in the new ‘long-run’ equilibrium, after internal migration takes place and a new equilibrium is reached. The last three rows report the implied elasticities of wages, rents and internal migration to the inflow of foreign-born and are directly comparable with the estimated coefficients $\gamma_w, \gamma_r, \gamma_E$ reported in Table 5.

The first column of Table 6 (Specification I) shows the results from the main simulation that uses the baseline choice for the parameters as described in the previous section. In particular the ‘preferred’ values for the parameters σ_k (equal to 6, 7, 7, 3) are used. Specification II employs the parameter values for σ_k ’s that are closer to the point estimates of Table 1 (equal to 7, 10, 10, 4). The remarkable feature of these two specifications is that they generate long-run elasticities of average wages and rents that match very closely the estimated range of elasticities in Table 5. In particular, γ_w is simulated to be between 0.35 and 0.42 while γ_r is between 1.18 and 1.58. The corresponding estimated ranges are (0.35 – 0.46) and (1.11 – 1.61) for γ_w and γ_r respectively. The parameter γ_E is more variable and not far from 0. Its variability in the simulation derives from the fact that different skill groups have different migration behavior (native *HSD* always move out while the other groups move in) so that the overall effect is uncertain. This has a correspondence, however, in the very large variability and imprecision of the estimated effect that was often not significantly different from 0 in Table 5. Specification III is shown for pure reference as it assumes very high values for the elasticity of substitution between US-born and foreign-born (not supported by the evidence). It is clear that the large and positive effect on average wages and rents depends heavily on the imperfect substitutability between US and foreign born. If, as in this specification, US and foreign-born are close to perfect substitute, then the effect on wages and rents is smaller and accompanied by a net out-migration of US-born workers.

Specifications IV to VII show the robustness of the simulated elasticity (especially γ_w and γ_r) to changes in the other parameters. Specification IV increases the elasticity of substitution between local services (produced by US and foreign born) to 7; Specification V reduces the share of total expenditure on housing services to 25%; Specification VI reduces the share of spending on food-entertainment to 15% and specification VII increases the elasticity of substitution between schooling groups to 2. Each specification produces values of γ_w and γ_r within the estimated range (Table 5) and values of γ_E either positive or very close to 0 confirming that there seem to be no strong tendency to out-migration of US-born in response to immigrants.

Thus, for plausible values of the parameters, our simple (and quite standard) model finds significant positive effects of immigration on average wages and rents of US born. Quite remarkably, the magnitude of this effect is equal to what the IV estimates across US cities show.

5 Conclusion

Increased movement of people across countries, commonly known as migrations, are a feature of the last decades just as increased movements of goods and capital. While in general economists are found among the staunchest supporters of freer trade and capital movements, they have been mostly arguing that migration hurts US native workers, in particular those with low skills. While it is hard to deny that, in any reasonable model, the relative increase of low skill workers will cause a decrease in their relative wage, here we are first interested in determining the overall (average) effect of immigration, aggregating across groups of US-born workers. It turns out empirically and theoretically that immigration, as we have known it during the nineties, had a sizeable beneficial effect on wages of US born workers. For a flow of migrants that increases total employment by 10%, with a distribution among skills just as the one observed in the nineties, US-born workers experience an increase of 3-4 percentage points of their wage. This happened because US-born and Foreign-born workers are not perfectly substitutable even when they have similar observable skills. Workers born, raised and partly educated in foreign environments are not identical to US-born and raised workers. Such differences that we may call the diversity of foreign-born, is the basis for the gains from immigration that accrue to US-born workers. Even a small amount of differences that translates in a relatively high elasticity of substitution between US and foreign-born workers (between 4 and 7) is enough to generate the average wage gains we that estimated from US metropolitan data using a reduced-form equation. We believe that sharpening the understanding of complementarities and substitutability between US and Foreign born in different sectors and skills, as well as using an aggregate production function approach are crucial steps in quantifying the benefits of immigrants to the US economy. We hope that this article may encourage a line of research into the "gains" from immigration, rooted into production complementarity (between workers and with physical capital) that may account for important and (so far) neglected effects of immigration.

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6 Appendix: Data and Definition of the Variables

6.1 Construction of average wage and average house values

The value of $\ln \bar{w}_{ct}$ used in Section 3.3 to calculate $\Delta \ln \bar{w}_{ct}$ is obtained separately for each census year as the MSA-specific intercept of the following Mincerian regression on individual data, after having selected only US-born individuals of individuals born abroad but US citizens since birth:

$$\ln w_{ict} = \ln \bar{w}_{ct} + \alpha(\textit{School})_i + \beta(\textit{Experience})_i + \gamma(\textit{Sex})_i + \delta(\textit{Race})_i + \theta(\textit{Marital})_i + \varepsilon_{ict}$$

The variable $\ln \bar{w}_{ct}$ captures 84 (or in the 1970-1990 sample 117) MSA-specific dummies. The variable *School* represents four dummies corresponding to the following groups: High School Dropouts, High School Graduates, College Dropouts and College Graduates. This variable is constructed using the variable "highest grade attended" (HIGRADEG) for the 1970 and 1980 Census, and the categorical variable (defined as *educ99* in the IPUMS files). Such variable has been converted into years of schooling using the correspondence developed in Park (1994). The variable *Experience* represents eight dummies for five-year groups of experience between 0 and 40 years. It is calculated as potential experience, namely, Age-years of schooling -6. The variable *Sex* is a dummy equal to 1 when the worker is a woman and 0 otherwise. The variable *Race* stand for five dummies corresponding to White, Black, Hispanic, Native and Asian. The variable *Marital* identifies three dummies corresponding to being single, being married or being divorced. The omitted dummies are such that the intercept captures the value for the reference group of High school graduates, 15-20 years of experience, white, male married. When we use hourly wage as measure of w_{ict} we obtain it by dividing the variable "wage and salary income" (previously converted in 2000 USA \$ using the CPI deflator) by the variable weeks worked last year and then by "hours worked last week (in the 1970 and 1980 Census) or by "Hours usually worked per week" (in the 1990 and 2000 Census). We selected people who were in the labor force and worked at least one week during the census year and received non-zero salary.

The value of $\ln \bar{r}_{ct}$ used in Section 3.3 to calculate $\Delta \ln \bar{r}_{ct}$ is also obtained separately for each census year as the average by MSA of monthly gross rent (RENTGRS) converted in 2000 US \$ using the CPI deflator, or of the Value of the house (VALUEH) also converted in 2000 US \$. Each value has been divided by the number of rooms (ROOMS) in the house to standardize for the size of the house and obtain a value per room, comparable across cities. Only US-born head of households have been included in the sample.

6.2 Construction of the Instrument

We first defined 56 countries (or group of countries) of origin of foreign-born that could be tracked consistently from the Census 1970 to the Census 2000. They accounted together for more than 98% of all foreign-born. These countries are: Canada, Atlantic Islands, Mexico, Central America, Cuba, West Indies, SOUTH AMERICA, Denmark, Finland, Iceland, Norway, Sweden, England, Scotland, Wales, Ireland, Belgium, France, Luxembourg, Netherlands, Switzerland, Albania, Greece, Italy, Portugal, Spain, Austria, Bulgaria, Czechoslovakia, Germany, Hungary, Poland, Romania, Yugoslavia, Estonia, Latvia, Lithuania, Russia, Rest of Europe, China, Japan, Korea, Philippines, Vietnam, India, Iran, Israel/Palestine, Jordan, Lebanon, Syria, Turkey, Rest of Asia, AFRICA, Australia and New Zealand, Pacific Islands, Abroad (unknown). From the Census 1970 we calculated the working population in skill group k (for $k = HSD, HSG, COD, COG$) in Metropolitan Area c (for $c = 1, \dots, 117$) from each of these nations and called it $L_{nkc1970}$. Using the overall Census (1970-2000) we calculated the overall growth rate of each skill by nation group (k by $n = 1, \dots, 56, 57$) for the whole US. Foreign-born in different skill groups grew because of differential immigration from nationality of origin as well as differential migration rate across skill groups. For each decade $t = 1970, 1980, 1990$ we can define the growth rate of a nation-skill group during that decade as $g_{nkt} = (L_{nkt+10} - L_{nkt})/L_{nkt}$. Finally we apply these nation-skill growth rates for each decade to the initial population in a skill-nationality group for each city c to obtain an imputed skill-nationality population of city c over the decades: $\widehat{L_{nkct+10}} = L_{nkc1970}(1 + g_{nkt})$ where the "hat" indicates that the value is imputed. Finally we can calculate using these imputed population the imputed shares of foreign born in each city and skill group for each census year (1980-2000). As the imputed variables are constructed using only national averages and the initial distribution of foreign-born, city-specific shocks occurred during the period (1970-2000) that affected actual migration into a city should be uncorrelated with them.

7 Appendix: Equilibrium of the City Model

Let us define w_{kh} as the wage per worker born in h with skill level k , p_Y the price per unit of tradable good Y , p_{Xh} the price per unit of non-tradable service h , and r the land rent. Define also $\Gamma \equiv \{HSD, HSG, COD, COG\}$ as the set of education levels and $\Theta \equiv \{H, F\}$ as the set of birthplaces.

7.1 Equilibrium Conditions

If we call \bar{w} the vector of w_{kh} 's and \bar{E} the associated vector of labor endowments, then aggregate income can be written as:

$$I = \bar{w}'\bar{E} + p_{XH}X_H + p_{XF}X_F + rT$$

Utility maximization and market clearing in all sectors imply:

$$I = \frac{\bar{w}'\bar{E}}{\alpha} \quad (21)$$

$$rT = \frac{1 - \alpha - \beta}{\alpha} \bar{w}'\bar{E} \quad (22)$$

Given (5), profit maximization requires:

$$p_Y \hat{A} = P_C \quad (23)$$

where \hat{A} is a constant defined in Section 2 and:

$$P_C = \left(\sum_{k \in \Gamma} \phi_k P_k^{1-\delta} \right)^{\frac{1}{1-\delta}}$$

$$\tau_k P_k = \left[\phi_{kH} (w_{kH})^{1-\sigma_k} + \phi_{kF} (w_{kF})^{1-\sigma_k} \right]^{\frac{1}{1-\sigma_k}}, \quad k \in \Gamma$$

are the price indices associated with the quantity indices C and C_k/τ_k respectively, $\phi_k \equiv (\tau_k)^{1-\delta}$ and $\phi_{kh} \equiv (\tau_{kh})^{1-\sigma_k}$.

The exact aggregation properties of the above quantity and price indices ensure that

$$P_C C = \bar{w}'\bar{E} \quad (24)$$

as well as $\sum_{k \in \Gamma} P_k C_k = P_C C$ and $\sum_{h \in \Theta} w_{kh} k_h = P_k C_k$. Exploiting these properties, profit maximization also implies:

$$P_k C_k = \phi_k \left(\frac{P_k}{P_C} \right)^{1-\delta} P_C C \quad (25)$$

$$w_{kh} k_h = \phi_{kh} \left(\frac{w_{kh}}{P_k} \right)^{1-\sigma_k} P_k C_k \quad (26)$$

for all $k \in \Gamma$ and $h \in \Theta$. These expressions can be easily manipulated to produce:

$$\phi_k \left(\frac{P_k}{P_C} \right)^{1-\delta} = \frac{\phi_k^{\frac{1}{\delta}} C_k^{\frac{\delta-1}{\delta}}}{\sum_{k \in \Gamma} \phi_k^{\frac{1}{\delta}} C_k^{\frac{\delta-1}{\delta}}} = \phi_k^{\frac{1}{\delta}} \left(\frac{C_k}{C} \right)^{\frac{\delta-1}{\delta}} \quad (27)$$

$$\phi_{kh} \left(\frac{w_{kh}}{P_k} \right)^{1-\sigma_k} = \frac{\phi_{kh}^{\frac{1}{\sigma_k}} k_h^{\frac{\sigma_k-1}{\sigma_k}}}{\phi_{kH}^{\frac{1}{\sigma_k}} k_H^{\frac{\sigma_k-1}{\sigma_k}} + \phi_{kF}^{\frac{1}{\sigma_k}} k_F^{\frac{\sigma_k-1}{\sigma_k}}} = \phi_{kh}^{\frac{1}{\sigma_k}} \left(\frac{k_h}{C_k} \right)^{\frac{\sigma_k-1}{\sigma_k}} \quad (28)$$

where σ_k is the elasticity of substitution between US and foreign born within skill level k .

Finally, we need to characterize the equilibrium prices of non-tradable services. To do this, we observe that for the utility we can exploit the same aggregation properties we used for tradable production. Specifically:

$$p_{Xh}h = \frac{\phi_{Xh}^{\frac{1}{\gamma}} h^{\frac{\gamma-1}{\gamma}}}{\phi_{XH}^{\frac{1}{\gamma}} H^{\frac{\gamma-1}{\gamma}} + \phi_{XF}^{\frac{1}{\gamma}} F^{\frac{\gamma-1}{\gamma}}} \beta I \quad (29)$$

for $h \in \Theta$.

7.2 Labor Market Clearing

We can represent the equilibrium as the intersection of labor demand and supply curves as follows. Demand for labor of skill level k and ethnic group h can be derived by considering (26), (25), (27), (28), and (24).

This gives:

$$w_{kh} = p_Y \cdot C^{\frac{1}{\delta}} \cdot \phi_{kh}^{\frac{1}{\sigma_k}} (h_k)^{-\frac{1}{\sigma_k}} \cdot \phi_k^{\frac{1}{\delta}} (C_k)^{-\frac{\sigma_k-\delta}{\delta\sigma_k}} \quad (30)$$

which depicts the (inverse) demand for workers born in h with skill level k as a negative relationship between w_{kh} and k_h .

At a free-mobility spatial equilibrium a worker must be indifferent about location irrespective of her birthplace and skill level. This is the case if she achieves the same level of indirect utility \bar{V}_{kh} in all cities. Given the utility function (19) this requires

$$w_{kh} = \bar{V}_{kh} p_Y^\alpha P_X^\beta r^{1-\alpha-\beta} \quad (31)$$

where

$$P_X = \left[\phi_{XH} (p_{XH})^{1-\gamma} + \phi_{XF} (p_{XF})^{1-\gamma} \right]^{\frac{1}{1-\gamma}}$$

is the exact price index associated with (20) such that $P_X X = \beta I$. Thus, by (21) and (22), we have

$$w_{kh} = \bar{V}_{kh} p_Y^\alpha P_X^\beta r^{1-\alpha-\beta} = \bar{V}_{kh} p_Y^\alpha \left(\frac{\beta}{X} \right)^\beta \left(\frac{1-\alpha-\beta}{T} \right)^{1-\alpha-\beta} \left(\frac{\bar{w}' \bar{E}}{\alpha} \right)^{1-\alpha}$$

which, by (24) and (23), can be rewritten as:

$$w_{kh} = p_Y \cdot \bar{V}_{kh} \cdot (\hat{A})^{1-\alpha} \cdot B \cdot \frac{(C)^{1-\alpha}}{(X)^\beta (T)^{1-\alpha-\beta}} \quad (32)$$

where $B \equiv (1/\alpha)^{1-\alpha} (\beta)^\beta (1-\alpha-\beta)^{1-\alpha-\beta}$. Given the definition of the composite C , (32) depicts the (inverse) supply of workers born in h with skill level k as a positive relationship between w_{kh} and k_h . With $k \in \Gamma$ and $h \in \Theta$, (30) and (32) generate a system of eight demands and eight supplies for foreign- and home-born labor. In its solution, we choose good Y as numéraire ($p_Y = 1$).

7.3 Further Details on Calibration and Simulation

We find the values of $\bar{V}_{kh} \cdot (\hat{A})^{1-\alpha}$ by assuming that the endowments of labor across skill and birthplace groups in 1990 correspond to the equilibrium allocations predicted by the model. Accordingly, the 16-dimensional system (30)-(32) can be solved in the following sixteen unknowns: eight wages w_{kh} and eight ‘adjusted’ indirect utilities $\bar{V}_{kh} \cdot (\hat{A})^{1-\alpha}$. The latter are held constant in all simulations.

The changes in foreign-born labor endowments from 1990 to 2000 are taken as exogenous. In evaluating the effects on impact, we also take US-born labor endowments as given. With fixed labor supplies, we are left with eight labor demands (30), which can be solved for eight wages. The final adjustment requires US-born workers to re-optimize in terms of location taking into account exogenous foreign-born migration. This requires to add four US-born labor supplies to the eight labor demands. The solution of this 12-dimensional system are eight equilibrium wages and four equilibrium quantities for US-born workers.

Figures and Tables

Figure 1

Percentage of Foreign-Born in US Population

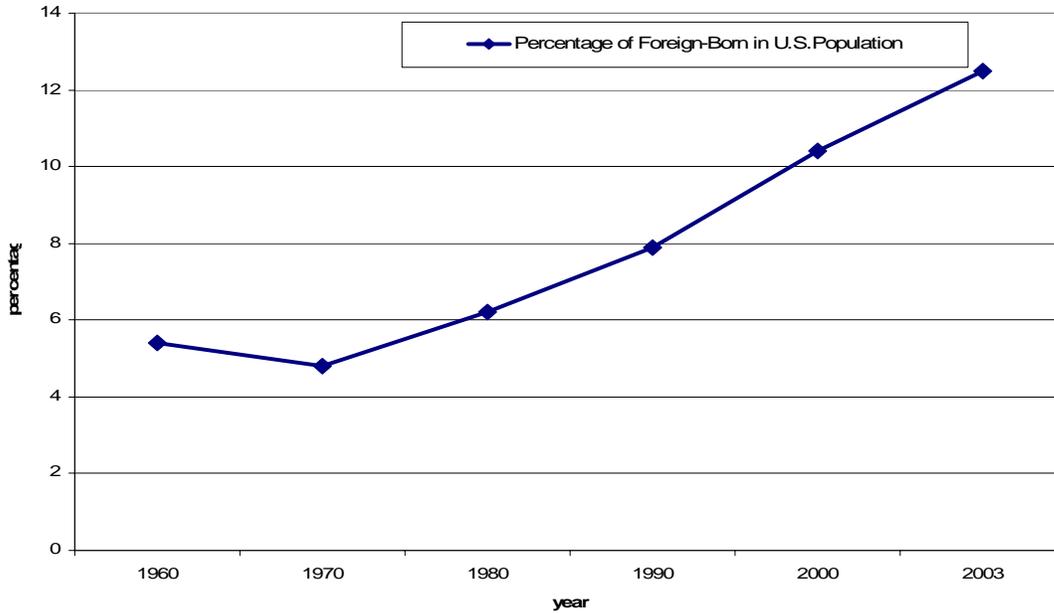


Figure 2

Change in Wage of US born and Change in Share of Foreign Born: 86 Metropolitan Areas, 1970-2000

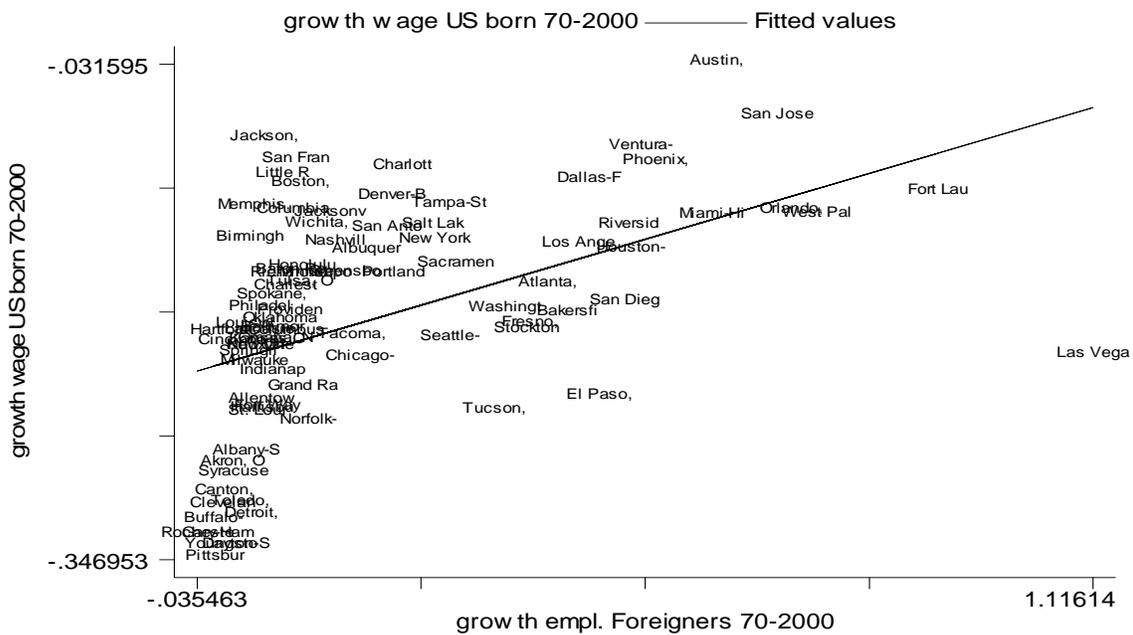


Figure 3
Change in Rent of US born and Change in Share of Foreign Born:
86 Metropolitan Areas, 1970-2000

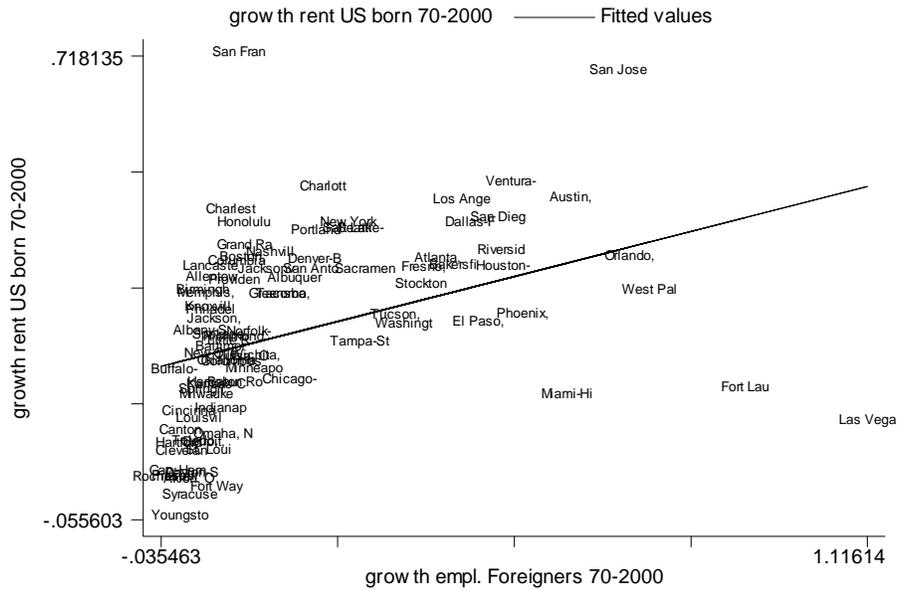


Figure 4
Change in Employment of US born and Change in Share of Foreign Born:
86 Metropolitan Areas, 1970-2000

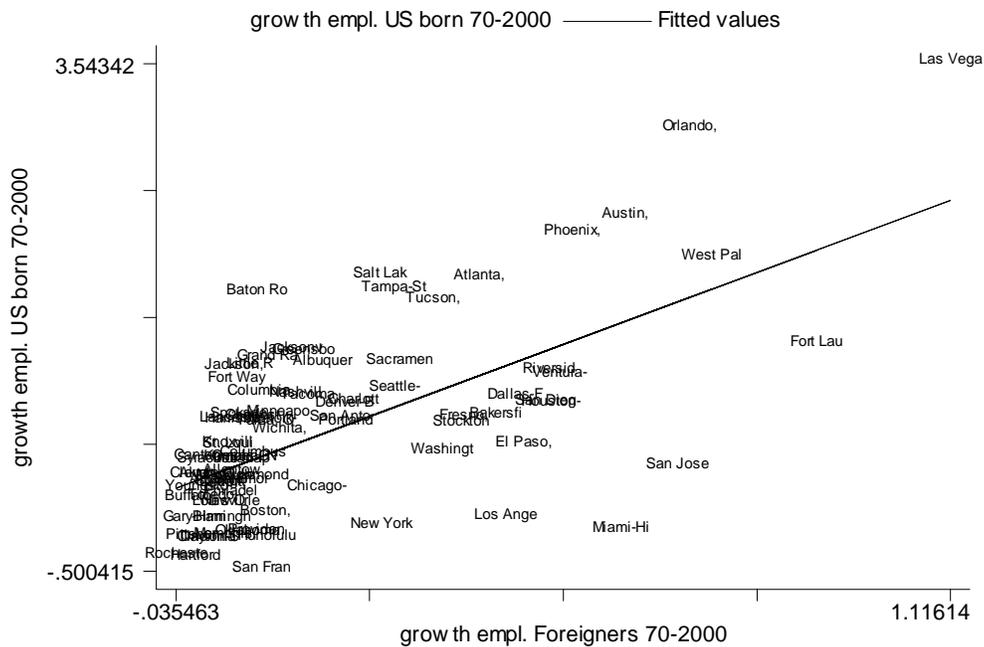


Table 1
Elasticity of substitution between US-Born and Foreign-Born workers
within the same education-experience group

Specification	Imposing same elasticity across different education groups	Allowing different elasticity for each education group
σ_{HSD}	7.7** (1.77)	7.10** (1.05)
σ_{HSG}	7.7** (1.77)	10.1** (3.02)
σ_{COD}	7.7** (1.77)	16.6 (11.1)
σ_{COG}	7.7** (1.77)	4.21** (0.66)
Experience by school effects	YES	YES
Year b y school effects	YES	YES
Year by Experience Effects	YES	YES
Instruments:	Log of foreign immigrants in each skill group	Log of foreign immigrants in each skill group
Observations	128	128

Notes: The parameters $-(1/\sigma_k)$ are estimated from the regression of relative wages (foreign-born/US born) on relative supply (foreign-born/US born) for 32 education-experience groups over four census years. The method of estimation is 2SLS. We compute σ_k and its standard error using the delta-method. Estimates in each column corresponds to a separate regression. Heteroscedasticity robust standard error in parenthesis *, ** significantly different from 0 at the 5%,1% level.

Table 2

Calculated Effects of Immigration (1990-2000) on Wages of US-born using the CES function.

Specification	Total Shocks by skill, 1990-2000 as % of 1990 employment	Parameter Values		Calculated Elasticities				
		δ	θ	(a)	(b)	(c)	(d)	(e)
	Δf_{HSG}	δ	σ_{HSD}	$\overline{\gamma_{wkj}^{\text{own}}}$	$\overline{\gamma_{wk}^{\text{own edu}}}$	$\gamma_{wkj}^{\text{total}}$	γ_w	%
	Δf_{HSG}	θ	σ_{SHG}	HSD	HSD	HSD		Increase
	Δf_{COD}		σ_{COD}	HSG	HSG	HSG		average
	Δf_{COG}		σ_{COG}	COD	COD	COD		wage of
				COG	COG	COG		U.S. born
								workers
1	1.9%	1.5	∞	-0.30	-0.60	-0.56	0.09	0.7%
Perfect	1.5%	3	∞	-0.31	-0.64	0.25		
Substitution	1.6%		∞	-0.32	-0.64	0.21		
US-Foreign	3.0%		∞	-0.32	-0.66	-0.02		
2	1.9%	1.5	7	-0.17	-0.48	-0.30	0.28	2.2%
Closest to	1.5%	3	10	-0.22	-0.55	0.31		
point	1.6%		10	-0.22	-0.55	0.28		
estimates	3.0%		4	-0.08	-0.41	0.32		
3 Preferred	1.9%	1.5	6	-0.17	-0.45	-0.30	0.34	2.7%
	1.5%	3	7	-0.18	-0.50	0.33		
	1.6%		7	-0.18	-0.50	0.31		
	3.0%		3	-0.00	-0.32	0.44		
COUNTERFACTUALS								
4	0	1.5	6	-0.17	-0.45	0.68	0.32	2.6%
no inflow of	3.4%	3	7	-0.18	-0.50	-0.06		
HSD	1.6%		7	-0.18	-0.50	0.34		
	3.0%		3	0.00	-0.32	0.47		
5	3.4%	1.5	6	-0.17	-0.45	-1.07	0.35	2.75%
no inflow of	0	3	7	-0.18	-0.50	0.64		
HSG	1.6%		7	-0.18	-0.50	0.28		
	3.0%		3	0.00	-0.32	0.41		
6	1.9%	1.5	6	-0.17	-0.45	-0.41	-0.03	-0.2%
no inflow of	1.5%	3	7	-0.18	-0.50	0.21		
COG	4.6%		7	-0.18	-0.50	-0.43		
	0%		3	0.00	-0.32	0.18		

Notes: The Values of $\overline{\gamma_{wkj}^{\text{own}}}$, $\overline{\gamma_{wk}^{\text{own edu}}}$, $\gamma_{wkj}^{\text{total}}$, γ_w are obtained using the formulas derived in the text. The initial composition of US-born and Foreign-born in each of the skill group replicates the composition of year 1990, as obtained from the IPUMS Census data. The inflows of foreign-born by education-experience group are calculated from the IPUMS 1990-2000 data. The elasticities δ and θ are taken from the literature: Katz and Murphy (1992) and Card and Lemieux (2001). As for the elasticities σ_k we experiment with different values, in the vicinity of the estimates of Table 1.

Table 3
Estimates of the own” wage Elasticity to flows of immigrants within the same skill-group

	Source, Method and Sample	Elasticity of US-born wages to immigration within the same skill group, keeping output constant	Calculated elasticity from table 2 (range for the parameter values in specification 2 and 3)
1	Borjas, (2003), IV, national 1960-2000, Skills: 32 experience-education groups	-0.29* (0.11)	$\overline{\gamma_{wkj}^{own}} =$ -0.13/-0.18
2	Ottaviano and Peri, IV, national, 1970-2000, 32 experience-education groups	-0.15* (0.04)	$\overline{\gamma_{wkj}^{own}} =$ -0.13/-0.18
3	Card (2001), IV 175 MSA’s 1985-1990. 6 Skill groups (occupation-based)	-0.03/-0.10* (0.02/0.04)	n.a.
4	Borjas, (2003), IV, national 1960-2000, Skills: 4 education groups	-0.75* (0.64)	$\overline{\gamma_{wk}^{own\ edu}} =$ -0.30/-0.40
5	Ottaviano and Peri, IV, 86 MSA’s, 1970-2000, 4 education groups.	-0.45* (0.25)	$\overline{\gamma_{wk}^{own\ edu}} =$ -0.30/-0.40

Notes:

1. Estimate is taken from the estimate of Equation 16, page 1363 in Borjas (2003)
2. Our Estimates, adopting the same methods and variable choices as Borjas (2003). Only differences: hourly wages, rather than weekly, exclude 1960 from the sample and use IPUMS (rather than CPS) as data source for 2000.
3. Estimates of the effect on US-born employment are taken from Table 4 in Card (2001), only the IV estimates (specification E,F and G). Estimates of the effect on US-born wages are taken from table 7 in Card (2001) only IV estimates for US-born Males (specification D,E,F,G).
4. Estimate is taken from the estimate of Equation 17, page 1363 in Borjas (2003)
5. Our Estimates, using cross-city variation and instruments, based on Card (2001) described in the main text.

Table 4
Estimates of the total effects of immigration on wages of US-born workers in each skill group

Specification:	I	II	III
Sample and Method of Estimation:	1970-2000 Panel IV 86 MSA	1970-1990 Panel IV 117 MSA	Calculated elasticity from Table 2 (range for the parameter values in specification 2 and 3)
γ_{wkj}^{total}	-0.10 (0.24)	-0.20 (0.17)	-0.30
(High school Dropouts)			
γ_{wkj}^{total}	0.15 (0.19)	0.20 (0.15)	0.31-0.33
(High School Graduates)			
γ_{wkj}^{total}	0.17 (0.20)	0.23 (0.15)	0.28-0.31
(College Dropouts)			
γ_{wkj}^{total}	0.40* (0.20)	0.40* (0.15)	0.31-0.44
(College Graduates)			
City Dummies	Yes	Yes	
Year Dummies	Yes	Yes	
Observations	344	351	

Note: The parameter estimates in each cell of Column I and II are from a separate panel regression. We use as dependent variable $\Delta \ln(w)_{ckt}$, the percentage change in average real (hourly) wage of US-born workers of education group k in city c for decade t. The average logarithmic wage for an education-group in a city in a census year is calculated as the city-specific intercept of a Mincerian regression of individual (log)wages on experience dummies, gender, race and marital status dummies restricting the sample to US-born individuals and running the regression separately for each education group and census year. In parentheses are Heteroskedasticity-robust standard errors.

Column III reports the values of the elasticity γ_{wkj}^{total} obtained from the calculations in Table 2, using the values of structural parameters in specification 2 and 3.

Table 5
Estimates of the total effects of immigration on average wages, housing value and in/outflows of
US-born residents: US Metropolitan Areas

Specification:	I	II
Sample and Method of Estimation:	1970-2000	1970-1990
	Panel IV	Panel IV
	86 MSA	117 MSA
γ_E	0.87 (0.80)	1.30 (0.74)
γ_w (real hourly wages)	0.46* (0.21)	0.38* (0.19)
γ_w (real yearly wages)	0.35* (0.19)	0.36* (0.22)
γ_r (real gross rents)	1.25* (0.40)	1.11* (0.30)
γ_r (real value of the house)	1.61* (0.75)	1.60* (0.60)
City Dummies	Yes	Yes
Year Dummies	Yes	Yes
Observations	344	351

The parameter estimate in each cell are from a separate panel regression. The explanatory variables in each regression are city dummies, time dummies and the increase in foreign-born workers as a percentage of initial total employment, as defined by Δf_{ct} in the text. Method of estimation: Instrumental variables using the “constructed” inflow of immigrants (from initial shares by nationality and average immigration rates into the US, described in the text) as Instrument for Δf .

Units of observation: Metropolitan Statistical Areas (MSA) consistently defined across Census years.

Heteroskedasticity-robust standard errors are reported in parenthesis.

*=significant at 5% confidence level.

First Row, Estimates of γ_E . The dependent variable is Δn_{ct} , the change in US-born workers in city (MSA) c during decade t as percentage of the initial total employment. Specification I uses a sample of 86 MSA’s for the 1970-2000 period, specification II uses 117 MSA’s for the 1970-1990 period.

Second and Third Row, Estimates of γ_w . The dependent variable is $\Delta \ln(w)_{ct}$, the percentage change in average real wage (hourly in the second and yearly in the third row) of US-born workers in city c for decade t . The average logarithmic wage for a city in a census year is calculated as the city-specific intercept of a mincerian regression of individual (log)wages on education dummies, experience dummies, gender, race and marital status dummies restricting the sample to US-born individuals and running the regression separately for each census year.

Fourth and Fifth Row, Estimates of γ_r . The dependent variable is $\Delta \ln(r)_{ct}$, the percentage change in average real monthly rent (fourth row) or house value (fifth row) divided by the number of rooms, for US-born individuals in city c for decade t .

Table 6
Simulation of the long-run impact of immigration shock on Wages, Housing Price and in/outflows of US-born residents, from the City-Model

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Immigration Shock : $\Delta f=8\%$, $\Delta f_{HSD}=1.9\%$, $\Delta f_{HSG}=1.5\%$, $\Delta f_{COD}=1.5\%$, $\Delta f_{COg}=3.0\%$.							
Parameter Values							
$1-\alpha-\beta$	0.2	0.2	0.2	0.2	0.25	0.2	0.2
β	0.2	0.2	0.2	0.2	0.2	0.15	0.2
γ	6	6	6	7	6	6	6
δ	1.8	1.8	1.8	1.8	1.8	1.8	2
σ_{HSD}	6	7	20	6	6	6	6
σ_{HSG}	7	10	20	7	7	7	7
σ_{COD}	7	10	20	7	7	7	7
σ_{COg}	3	4	20	3	3	3	3
Short-Run (Impact) Effect							
Change of average Wage US born	2.8%	2.0%	0.5%	2.8%	2.8%	2.8%	2.7%
Change of average Value of Houses	10.2%	9.3%	7.9%	10.2%	10.2%	10.2%	10%
Long-Run Effect							
Change of average Wage US born	3.4%	2.9%	1.5%	3.5%	3.6%	3.6%	3.3%
Change of average Value of Houses	12.9%	9.7%	4.2%	12.6%	10.7%	10.7%	13%
Total Migration of US born	2.3%	-0.3%	-4.9%	2.0%	-0.1%	-0.1%	2.6%
Implied Long-Run Elasticities							
γ_w	0.42	0.35	0.19	0.42	0.44	0.44	0.40
γ_r	1.58	1.18	0.52	1.55	1.31	1.32	1.59
γ_E	0.28	-0.06	-0.61	0.24	-0.02	-0.01	0.31

The Value of all other parameters as well as the initial conditions in the supply of US-born and Foreign-born workers of each skill group are constant across simulations and are reported in the section “Simulation of the Model” in the text. The simulated shock equals in magnitude and skill composition the inflow of foreign-born workers in the period 1990-2000.