Immigration and the Human Capital of Natives *

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Abstract

The economics literature has not reached consensus about how much (or even whether) immigration reduces wages among native-born workers. Area-based studies tend to find small if any effects. On the other hand, direct estimates of the elasticity of substitution between immigrant and native-born workers tend to be large, which implies large wage effects. In this paper, I show that elasticity of substitution estimates are upward-biased if native-born workers augment their human capital in the face of rising immigration. I then use the National Education Longitudinal Study (NELS:88) and U.S. Census data to show that low-skilled immigration induces natives to attain more years of schooling, improve their performance in school, and take jobs that involve communication-intensive tasks for which they (native English speakers) have a comparative advantage. My empirical findings imply that previous estimates of the elasticity of substitution are probably too high, which helps reconcile competing perspectives about immigration's effects on native-born workers' wages.

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1 Introduction

The economics literature has not reached consensus about how much (or even whether) immigration reduces wages among native-born workers. This is true despite much attention and high stakes. Immigrants make up a very large share of many cities in the United States and immigration policy has been debated vigorously at the federal and state levels. The degree to which immigrant workers compete with native-born workers for jobs and earnings is an important parameter for defining any optimal immigration policy (i.e., whom to admit).

One major strand of the economics literature (e.g., Card 2005) demonstrates that native-born workers in high-immigration areas do not earn substantially lower wages than similar workers in low-immigration areas.[1] Typical studies accommodate unobserved area-specific factors that affect local wages and immigration by instrumenting for immigration (typically with pre-existing ethnic enclaves). Critics have suggested that natives migrate out of local areas with large local immigration flows, which would attenuate estimates of wage effects even if competition for jobs and true (nationwide) earnings effects are large (Borjas 2003). However, empirical work on natives' migration responses is also controversial, including findings of essentially zero and also substantial responses.[2] A competing strand of the immigration literature (e.g., Borjas 2003) estimates large elasticities of substitution between immigrant and native-born workers. A large substitution elasticity implies large wage effects. Borjas, Grogger, and Hanson (2011) argue that immigrant and native workers are effectively perfect substitutes, so immigration reduces natives' wages substantially.

Below, I describe how researchers estimate the elasticity of substitution between immigrant and native-born workers. I then show that natives' responses to immigration affect the consistency of those elasticity estimates. In particular, young natives anticipating competition with relatively low-skilled immigrant workers may differentiate their

[1] Identification often comes from changes over time as well.

[2] Card and DiNardo (2001) and Peri and Sparber (2011) argue that migration responses are small. Borjas (2006) disagrees.

own human capital from the abundant supply of human capital specific to immigrants. Native-born children may work harder at school to increase their own labor market productivity. If they do, then previous studies have mis-measured labor inputs when estimating substitution elasticities. The result is an upward bias: researchers infer too much substitutability and thereby overly large effects of immigration on natives' wages.

After demonstrating that natives' human capital investment responses to immigration would bias substitution elasticity estimates, I demonstrate that native-born children do respond to local low-skilled immigration. I study behavior of native-born children in the National Education Longitudinal Study (NELS:88) responding to immigration flows that I measure in the U.S. Census. I find that low-skilled immigration flows induce local native youth to attain more secondary and post-secondary schooling. The result uses plausibly exogenous variation in local immigration (based on pre-existing ethnic enclaves) and is robust to controls including mother's education and also characteristics of the student's school. I control for immigration's effect on peers at school by including in some specifications the proportion of limited-English-speaking students in the native-born respondent's school. I also investigate mechanisms through which natives increase their academic successes: students exposed to more low-skilled immigrants tend to have higher school attendance, grades, and test scores.

Finally, I study NELS:88 respondents' early-career jobs to test a recent hypothesis (in Peri and Sparber 2009): low-skilled immigrants, who have relatively low English-language skills, induce low-skilled natives to invest in communication-oriented job skills rather than manual skills. Peri and Sparber (2009) describe the relationship in an equilibrium model of behavior and find support for it in U.S. Census data. Native-born respondents to the NELS:88 with more early immigration exposure choose jobs where they are more likely to use word-processing and e-mail, and less likely to use manual skills. From changes in natives' job tasks, I infer that natives invested in communication skills as a way to differentiate themselves from low-skilled immigrants in the local labor market. This finding complements Peri and Sparber (2009) and points to another way that native

workers change their behavior to attenuate wage losses due to immigration.

The next section shows that estimates of the elasticity of substitution between immigrant and native-born workers are upward-biased when natives increase their human capital in response to immigration. I then describe prior research on the relationship between immigration and natives' human capital development, much of which focuses on incentives in the classroom rather than the labor market. I then demonstrate that behavior of NELS:88 respondents implies previous estimates of the elasticity of substitution between immigrant and native-born workers are probably too high. The implication is that wage effects of immigration are lower than a major strand of the literature implies (e.g., Borjas 2003). This finding is important because it provides some reconciliation between two very different views of immigration's impacts on native-born workers.

2 Bias in Substitution Elasticity Estimates

In this section, I describe how reactions of native-born workers would imply that previous estimates of the substitution elasticity between immigrant and native-born workers are upward-biased. I begin by describing how the estimation procedure typically works. Adopting the notation in Borjas, Grogger, and Hanson (2011), L^n_{jkt} is the labor input from people in education group j, experience group k, year t, and nationality group n. Nationality F means a foreign-born worker, while D (domestic) means a native-born worker. The total labor input in an education-experience-year cell is $[\psi(L^F_{jkt})^\lambda + (1-\psi)(L^D_{jkt})^\lambda]^{1/\lambda}$. The elasticity of substitution is $\sigma_N = 1/(1-\lambda)$. If wages equal marginal products, then

$$\ln\left(\frac{w^F_{jkt}}{w^D_{jkt}}\right) = \phi - \frac{1}{\sigma_N}\ln\left(\frac{L^F_{jkt}}{L^D_{jkt}}\right) \tag{1}$$

where $\phi \equiv \ln[\psi/(1-\psi)]$. See Appendix A below for a derivation of Equation 1.

Borjas, Grogger, and Hanson (2011) and Ottaviano and Peri (2011) are two of the studies employing this framework. Their method is to regress foreign-to-native relative wages

on foreign-to-native relative employment where observations describe cells defined by education levels, experience levels, and years. Fixed effects help make the case that variation in relative employment is related to exogenous shifts in immigrant supply rather than demand-side factors. Call the regression coefficient on log relative employment $\widehat{\beta}$, so that the estimate of the elasticity of substitution is $\widehat{\sigma}_N = -1/\widehat{\beta}$ (motivated by Equation 1). If $\widehat{\beta}$ is effectively zero (Borjas, et al.'s finding), then conclude that the elasticity of substitution between foreign-born and native workers is infinite (perfect substitutes). This implies that immigration's effect on natives' wages should be large. The intuition is that when foreign-born labor becomes suddenly more abundant, its compensation does not change relative to native-born workers' wages: wages of both walk down the demand curve together (at the same rate) following the immigration supply shock. The idea follows Card and Lemieux (2001) and Borjas (2003).[3]

But the framework remains very simple on the labor supply side. What if immigration into an education-experience-year cell induces native workers in that cell to attain more human capital? Competition for jobs provides a strong incentive. Natives might react by trying harder at school or emphasizing skills for which they have comparative advantages. Such behavior can be incorporated into the framework above. Let there be a difference between numbers of workers and of effective labor units to incorporate the idea that a worker with given observed traits (e.g., experience) may increase her (unobserved) human capital and thereby her effectiveness at work. In the analysis above, L^F_{jkt} is the number of effective labor units from foreign-born workers, and L^D_{jkt} is the number of effective labor units from native-born workers. To simplify notation, I will suppress the jkt subscripts from now on. Suppose the *number* of foreign-born workers (N^F) is the same as effective foreign-born labor: $L^F = N^F$.

However, native-born labor within the same (observational) education-experience-year cell augments its effectiveness in response to immigration. Let the fraction of foreign-

[3]Jaeger (2007) employs a similar strategy to estimate large elasticities of substitution between foreign-born and native-born workers. He exploits variation in immigration across cities, rather than education-experience cells.

born workers in an education-experience-year cell be $s \equiv N^F/(N^F + N^D)$. Native-born workers respond to the share of foreign-born workers by augmenting their human capital (labor productivity) in the following way:

$$L^D = \delta(s)N^D.$$

$\delta(s)$ is a continuous function such that $\delta'(s) > 0$, to capture increased effectiveness of native-born labor as more foreign-born workers enter the market. A result of this set-up is that counts of workers (or hours) mis-measure the effectiveness of native-born labor in the production function. This will induce bias in estimates of the elasticity of substitution between foreign-born and native-born labor (σ_N).[4]

To see this, plug $L^F = N^F$ and $L^D = \delta(s)N^D$ into Equation 1 (still suppressing jkt subscripts):

$$\begin{aligned} \ln\left(\frac{w^F}{w^D}\right) &= \phi - \frac{1}{\sigma_N}\ln\left(\frac{N^F}{\delta(s)N^D}\right) \\ &= \phi - \frac{1}{\sigma_N}\ln\left(\frac{N^F}{N^D}\right) + \frac{1}{\sigma_N}\ln(\delta(s)) \end{aligned} \tag{2}$$

The empirical exercise in Ottaviano and Peri (2011) and Borjas, Grogger, and Hanson (2011) is to regress log relative wages of foreign- and native-born labor on log relative numbers of foreign-born and native workers. The coefficient on the log ratio of foreign-

[4]I thought earlier that natives' human capital augmentation may be captured more simply as a reduction of ψ, the parameter that measures the relative effectiveness of immigrant labor inputs. As a result, human capital augmentation would show up empirically in estimates of ϕ, leaving estimates of σ_N unbiased. However, natives' responses must work through changes in L^D as above. When immigrants increase in a particular education-experience cell, the natives who respond are those in that education-experience cell. This increases the effective labor supply of native-born workers in that cell, not overall. But ψ measures the relative effectiveness of all immigrants. Since it does not have a jkt subscript, ψ is too blunt an instrument for modeling the native human capital augmentation idea.

born and native workers is (differentiating Equation 2)

$$\begin{aligned}
\widehat{\beta} \equiv \frac{d\ln(w^F/w^D)}{d\ln(N^F/N^D)} &= \frac{N^F}{N^D}\frac{d\ln(w^F/w^D)}{d(N^F/N^D)} \\
&= \frac{N^F}{N^D}\left[0 - \frac{1}{\sigma_N}\left(\frac{N^F}{N^D}\right)^{-1} + \frac{1}{\sigma_N}[\delta(s)]^{-1}\delta'(s)\frac{ds}{d(N^F/N^D)}\right] \\
&= -\frac{1}{\sigma_N} + \frac{1}{\sigma_N}\frac{\delta'(s)}{\delta(s)}\frac{N^F/N^D}{(1+N^F/N^D)^2} \\
&= \frac{1}{\sigma_N}\left[-1 + \frac{s(1-s)\delta'(s)}{\delta(s)}\right] \\
&= \frac{1}{\sigma_N}\left[\frac{-\delta(s) + s(1-s)\delta'(s)}{\delta(s)}\right] \qquad (3)
\end{aligned}$$

The third and fourth equalities used the derivations in the footnote below.[5] The elasticity of substitution estimate from the empirical exercise is $\widehat{\sigma}_N = -1/\widehat{\beta}$. Using Equation 3, this estimate is related to the true elasticity of substitution (σ_N) as follows:

$$\begin{aligned}
\widehat{\sigma}_N = -\widehat{\beta}^{-1} &= -\sigma_N\left[\frac{\delta(s)}{-\delta(s) + s(1-s)\delta'(s)}\right] \\
&= \sigma_N\left[\frac{\delta(s)}{\delta(s) - s(1-s)\delta'(s)}\right] \qquad (4)
\end{aligned}$$

[5]The third equality:

$$\begin{aligned}
\frac{ds}{d(N^F/N^D)} &= d\left[\frac{N^F/N^D}{1+N^F/N^D}\right] \Big/ d(N^F/N^D) \\
&= \frac{1 + N^F/N^D - N^F/N^D}{(1+N^F/N^D)^2} \\
&= \frac{1}{(1+N^F/N^D)^2}
\end{aligned}$$

The fourth equality:

$$\begin{aligned}
\frac{N^F/N^D}{(1+N^F/N^D)^2} &= \frac{N^F/N^D}{1 + 2N^F/N^D + (N^F/N^D)^2} \times \frac{(N^D)^2}{(N^D)^2} \\
&= \frac{N^F N^D}{(N^F+N^D)^2} \\
&= s\left(\frac{N^D}{N^F+N^D} + \frac{N^F}{N^F+N^D} - \frac{N^F}{N^F+N^D}\right) \\
&= s(1-s)
\end{aligned}$$

It is clear that $s(1-s)\delta'(s) > 0$, since s is the proportion foreign-born in the population, and $\delta'(s) > 0$ by assumption (native workers increase their skills in the presence of more immigrants). In addition, $\delta(s) > 0$, since otherwise effective labor units would be negative. Therefore, the term in brackets is greater than one so long as $s(1-s)\delta'(s) < \delta(s)$, which is likely.[6]

If natives' human capital stock is fixed, so $\delta'(s) = 0$, then Equation 4 implies that $\widehat{\sigma}_N = \sigma_N$: there is no bias in Ottaviano and Peri (2011) and Borjas, Grogger, and Hanson (2011). But if $\delta'(s) > 0$ (as I demonstrate below) and Equation 4's term in brackets is greater than one (which is likely), then $\widehat{\sigma}_N > \sigma_N$. This means that prior estimates of the elasticity of substitution between foreign-born and native-born labor are upward-biased. In addition, the bias is greater ($\widehat{\sigma}_N$ is further from σ_N) the greater is natives' human capital investment response to immigration ($\delta'(s)$).

The bias implied by Equation 4 is potentially large. If $\delta(s) = \ln(1+s)$, then the true elasticity σ_N is about one quarter the size of the estimated elasticity $\widehat{\sigma}_N$ when the immigrant share s is 0.2. σ_N is about half the size of the estimated elasticity $\widehat{\sigma}_N$ when $s = 0.4$. Such large discrepancies imply significantly different degrees of substitutability between foreign-born and native workers.

Below, I document evidence that native workers respond to immigration by investing more in their human capital: $\delta'(s) > 0$. The next section describes some of the previous research on the relationship between immigration and natives' human capital, and how my empirical work adds to this literature.

3 Prior literature on immigration and natives' schooling

In this paper, I argue that local immigration flows induce native-born youth to invest more in their human capital. I focus on effects of immigrants with relatively low educa-

[6] $\delta(s)$ is probably in the neighborhood of one, since foreign-born and native-born workers with similar education and experience are probably similarly productive. Since s is a fraction, $s(1-s)$ is at most 0.25. So $\delta'(s)$, the slope of the human capital augmentation function, would need to be very large (likely greater than 4) to make the term in brackets negative.

tion, a particularly important group in the U.S.[7] Only a small number of studies focus on this relationship. Betts (1998) provides a useful framework for thinking about the effect of immigration on natives' education through two channels. The first is through the quality of schooling. A large local inflow of immigrants–in particular, low-skilled immigrants–will tend to reduce the schooling resources available for natives. For example, shifting teachers to English-proficiency classes will increase class sizes for native-born students. Diminished school resources reduce the value of education to natives and induce them to get less of it.[8]

On the other hand, recent immigration has increased the market supply of low-skilled workers and should in theory put downward pressure on wages and employment probabilities for low-skilled residents. To the extent that low-skilled workers complement the productivity of high-skilled workers, wages in jobs requiring more education may rise. Both mechanisms increase the return to education, and native-born youth in the area with more immigration may have a strong incentive to acquire more schooling. Such increased education may be viewed as socially desirable if native-born youth under-invest in their own schooling or if education generates positive externalities.[9]

Most of the previous literature on immigration and natives' education in the United States uses Census data to measure effects on natives.[10] Betts (1998) documents a neg-

[7]Card (2005) and others have documented that immigrants to the U.S. since the late 1960s are much less educated than natives on average. Reasons include global population shifts and the 1965 Immigration Act, which widened the national origins of immigrants to the U.S.

[8]The literature on the effects of immigrant students on native students' school performance yields mixed results. For example, Diette and Oyelere (2012) demonstrate that large inflows of immigrants to North Carolina (proxied by each school's share of students with limited English proficiency) increased test scores of relatively low-ability native-born students but decreased test scores of abler natives. Jensen and Rasmussen (2011) find negative effects of immigrants on native-born students in Denmark. Neymotin (2009) shows that immigration probably did not reduce SAT scores attained by native-born students in Texas and California and perhaps increased them.

[9]Among many points of disagreement in a symposium on human capital policy, Carneiro and Heckman (2003) and Krueger (2003) agree that there are many U.S. residents who would be better off if they invested more in human capital. Lange and Topel (2006) and Moretti (2004) describe some evidence of local positive spillovers from education, although they both note that the empirical evidence is mixed.

[10]An exception is Llull (2010). She estimates a dynamic structural model of human capital attainment, occupational choice (blue or white collar), and wages. She uses the National Longitudinal Survey of Youth, 1979–a panel data set describing a cohort of individuals in the U.S. from 1979 to the present–and the Current Population Survey. She finds that immigration reduces wages even though natives increase their education in response. Eberhard (2012) uses the CPS to calibrate a general equilibrium model of immigration, human

ative relationship between state-level immigration and the probability that native-born black and Hispanic students complete high school in the 1980 and 1990 Censuses.[11] Betts (1998) compares schooling of native-born adults (aged 19-25 and 24-30, respectively) with immigration in the state where those natives live at the time of the Census. But schooling decisions should be more influenced by immigration when natives are children, and selective migration may confound the relationship between immigration and education levels of adults.

Hunt (2012) uses 1940 to 2000 decennial Census samples to expand upon the work of Betts (1998) and Betts and Lofstrom (2000): she assigns immigration flows to natives at younger ages based on birth states, distinguishes among more- and less-educated immigrants, measures natives' education consistently over time,[12] and instruments for state-level immigration flows (with lagged immigrant origins). She finds that the presence of immigrants in a state *raises* the probability that natives attain 12 years of schooling, with particularly large effects in the black native-born population. Also with U.S. decennial Census data, Jackson (2009) shows that college enrollment rates among the native-born increase with the entry of more low-skilled immigrants to the state's labor market. This is the case in specifications that account for college "crowd-out" by controlling for the number of immigrant college students in the state.[13]

Such analysis with Census data clearly benefits from very large samples and the ability to measure changes over time (e.g., comparing differential changes in California and Oregon across the 1980, 1990, and 2000 Censuses). Large samples allow separate estimation

capital accumulation, and wages. In counterfactual exercises, he finds that natives increase their human capital accumulation in response to nationwide immigration shocks.

[11] Betts and Lofstrom (2000)–an extension using the same methods but adding the 1970 Census and white and Asian natives–also find a negative relationship between immigration and schooling levels of natives.

[12] The 1980 Census asks respondents how many years of schooling they have. The 1990 Census asks for information about degrees obtained. Betts (1998) measures high school completion as getting 12 years of schooling in 1980 and a high school diploma in 1990. Hunt (2012) explains (in footnote 10) that this change in the dependent variable's definition induces Bett's negative coefficient among Hispanics. Hunt (2012) defines high school completion consistently in all years as getting 12 years of schooling.

[13] Smith (2010) estimates immigration effects on youth outcomes, including whether the teenager is in school. He uses decennial Census and annual American Community Survey data. He finds small positive effects of local immigration flows among white girls and smaller positive effects for white boys. He also obtains somewhat noisy estimates of immigration on a cohort's future earnings.

for different racial and ethnic groups (e.g., to discern whether immigration differentially affects black and white natives). On the other hand, Census data do not provide ideal outcome measures, and the public-use data do not allow very precise location of individuals.

In this paper, I exploit features of the NELS:88 data set that improve upon analyses of Census data in several ways. The NELS:88 collects information from respondents and their parents, so I can control for parent's education when investigating other determinants of schooling choices. The NELS:88 surveys principals and teachers in respondents' schools, so I can control for specific school resources and the student body. The NELS:88's focus on education translates into more accurate measures of diploma receipt and specific certification, in comparison to less-informative Census information about years of schooling. In particular, the NELS:88 distinguishes between a high school diploma and the General Educational Development (GED) credential and also collects information about students' curricula (e.g., Advanced Placement and vocational classes). I also use NELS:88 information on attitudes and expectations of respondents and their early-career experiences.

Another weakness of Census-based analyses is that they match respondents with local immigrant flows that may not be relevant to them. Studies tend to associate with respondents the state-level immigration flows where they were born or where they live in their 20s. There are two problems with this. First, young people are geographically mobile, and their birthplace or residence in their 20s might be quite different from their residence when making educational choices. Second, some states are very large and contain locations with differing immigration histories. The more precise timing and location information in the NELS:88 allow me to make a more informative match between immigration waves and natives. Specifically, I measure immigration flows facing natives in local labor markets rather than states, and I match these immigration flows to the place where NELS:88 respondents attend the 8th grade.[14]

[14]I measure immigration flows at the commuting zone (CZ) level. I describe commuting zones in detail below.

4 Data and empirical strategy

The empirical goal in this paper is to estimate the effect of low-skilled immigration on human capital investments among young native-born residents nearby.[15] The data requirements include measures of local immigration flows and human capital investment behavior. In this paper, local areas are commuting zones (CZs), which are collections of adjacent U.S. counties.[16] Studies of immigration in the U.S. commonly analyze states or metropolitan statistical areas (MSAs). In contrast to states, commuting zones are good approximations of self-contained local labor markets. Their boundaries are very similar to metropolitan statistical areas (MSAs) in cities, but CZs describe local markets in rural areas as well. Similarly-skilled people living in the same CZ (e.g., immigrants and natives) apply for and work in roughly the same jobs. Outside the CZ, jobs are mostly out of commuting distance and would require a relatively long-distance move to accept.

For the purpose of assessing immigration's effect on native human capital investment, the immigration measure could be either a stock or a flow. The presence of many immigrants in the local labor market may induce native youth to invest more in education. On the other hand, recent *growth* in immigration may be more salient than current stocks in influencing natives' decisions. I focus here on immigration flows.[17] That is, I associate local natives' skill investment decisions with recent increases in the local foreign-born population. One reason is that I expect large increases to be more salient (noticed by local natives) than large stocks. In addition, large increases probably imply more about future conditions than large current stocks imply. Suppose there are two cities: A and B. City A's population is 5 percent foreign-born in 1980 and 10 percent foreign-born in 1990. City B's population is 10 percent foreign-born in both 1980 and 1990. It seems reasonable to expect based on trends that in later years, City A will have the larger share of immigrants. Hence,

[15] Using the model language of Section 2, the empirical work is a demonstration that $\delta'(s) > 0$.

[16] See Tolbert and Sizer (1996) for a description of how CZs were identified. They use journey-to-work data from the 1990 Census to identify counties with strong labor market links. There are 741 CZs in the U.S.

[17] Alternative analyses that measure immigration as a stock (i.e., percent of local residents who are low-skilled immigrants) yield findings similar to those described below.

students attending high school in City A in 1990 will have a greater incentive to invest in schooling, since they reasonably expect greater competition with immigrant laborers than do students in City B. The alternative stock-based immigration measure would treat City A and City B identically and miss the important dynamic incentives that students face when investing in skills with future pay-offs.

I use the U.S. Census data in IPUMS (Ruggles, et al. 2010) to count immigrants by commuting zone (CZ). Let c index CZs of residence. $I_{c,t}$ is the number of (low-skilled) immigrants in CZ c in Census year t. The specific measure of a local immigration flow is:

$$\Delta I_{c,1990} = \ln I_{c,1990} - \ln I_{c,1980}. \tag{5}$$

I collect data from the 1970, 1980, and 1990 Censuses.[18] I identify the commuting zone (CZ) where each respondent lives using the county group of residence variables in IPUMS.[19] Immigrants are respondents who were born outside of U.S. territories and either a naturalized U.S. citizen or not a citizen.[20] To focus on relatively low-skilled immigration, I select only immigrants with a high school education or less. Evidence that high school dropouts and high school graduates are close-to-perfect substitutes with each other but imperfect substitutes with college-educated workers motivates this working definition of "low-skilled" (Card 2009).

Table 1 shows summary statistics describing immigration in the 741 CZs in the 1990 Census. The first row displays the distribution of 1990 CZ immigrant shares. Not surprisingly, there is a large variance: some CZs have almost no immigrants, while in some CZs

[18]The specific data sets are the 1970 form 1 metro and form 2 metro samples, the 1980 5 percent sample, and the 1990 5 percent sample. The citizenship variable is not available in the 1970 form 2 metro sample. For that sample, I impute citizenship status based on the likelihood of citizenship in the 1970 form 1 metro sample conditional on respondents' birthplace, age, and education.

[19]The data identify the county group where each respondent lives (called "county groups" in 1970 and 1980 and called "public-use microdata areas" (PUMAs) in 1990). Most county groups by these definitions are completely enclosed in a CZ, so the identity of the respondent's CZ is clear. Sometimes county groups intersect with more than one CZ; in these cases, I assign Census respondents to CZs based on the proportion overlap between county group and CZ populations.

[20]People born in any of the 50 states, Washington, D.C., or outlying areas and territories (American Samoa, Guam, Puerto Rico, U.S. Virgin Islands) are "natives" in the analysis.

immigrants account for more than 20 percent of the population. The second row describes the percent less-educated immigrants (with a high school degree or less) in total CZ population. Again, the variance across CZs is large. The third row shows that less-educated immigrants make up a large share of immigrants in all CZs and the majority in most CZs. The fourth row of Table 1 documents flows of low-skilled immigrants between 1980 and 1990, which is the main independent variable in the analysis below. Most CZs in the 1980s actually experienced reductions in the number of low-skilled immigrants, but there were some CZs with very large increases. The very large percent increases included CZs with both large and small populations, so the variety across CZs is not just a consequence of tiny immigrant populations doubling, for example.

I use the National Education Longitudinal Study (NELS:88) to measure human capital investments of U.S. native youth. The NELS:88 was administered by the U.S. Department of Education. It began with a representative sample of 8th-graders in U.S. schools in 1988. Follow-up surveys were fielded in 1990, 1992, 1994, and 2000, and include responses from students, parents, teachers, and school administrators. Using school and residence zip codes in the restricted-access version of the NELS:88, I identify the local labor market where each respondent attended secondary school. In practice, I assign to each sample member the immigration flow in the CZ where she attended the 8th grade (when respondents were about 14 years old).

The NELS:88 provides quite a large sample for a longitudinal survey. The base-year survey reached almost 25,000 students. The next two waves of the survey are similarly large. I use these large samples when measuring respondents' behaviors and attitudes during secondary school. The final follow-up survey (in 2000) includes a subsample of previous respondents (about 12,140 of them), and I use this sample when measuring final educational attainment and early-career job characteristics.[21]

My focus is on the reaction of local native youth to immigration flows. Some of the NELS:88 sample members are immigrants themselves. I select only those NELS:88 re-

[21] For details about the sampling procedure, see Curtin, et al. (2002).

spondents who were born in the U.S. (or Puerto Rico) and whose parents were born in the U.S. (or Puerto Rico). Hence, the sample excludes first and second generation immigrants. I do not restrict the sample by race or ethnicity.[22] I also keep respondents who move across local labor markets at any time during the sample, so educational investments and work experiences may not occur where the initial immigration flow was experienced.

The first measure of human capital investment that I use is completion of high school. The NELS:88 separately identifies students who graduated from high school and those who obtained a GED credential, and I treat GED-holders as high school dropouts, unless they completed post-secondary school after the GED. I also investigate a second measure of educational attainment: school attendance after high school. The NELS:88 asked respondents whether they had attended any "college, university, or vocational, technical or trade school for academic credit." Many of the post-secondary attenders did not finish their program. An alternative education measure I investigate is the receipt of any post-secondary certificate, license, or degree (associate's, bachelor's, or graduate degrees).

Table 2 displays average characteristics of NELS:88 sample members. I measure educational attainment at a consistent age (26 years old), by which most respondents have gotten as much schooling as they ever will. The first panel of the table (column 2) shows that half of the sample are women and most respondents are white and not Hispanic (the omitted race/ethnicity category). Some specifications below control for mother's education, which is an important predictor of own education; the average mother had a little more than 13 years of school. Columns 4 and 6 break down NELS:88 respondents' characteristics by the 1980-1990 low-skilled immigrant growth rates in their 8th grade CZs. The differences are somewhat small, except that the share of Hispanic NELS:88 respondents in high-immigration CZs is much higher than in low-immigration CZs. Since much of the contemporary immigration was from Central America, and ethnic groups tend to

[22]Results reported below are similar in NELS:88 samples that include children of immigrants. I experimented with analyses on samples of only black respondents or only Hispanic respondents. The sample sizes tended to be too small to support much statistical precision. Separating by race and ethnicity category is a productive exercise, though. See Betts (1998) and Hunt (2012) with larger Census samples.

cluster near each other, this is not surprising. I control for all of these demographic and background variables when assessing the relationship between local immigration and natives' schooling levels.

The second panel of Table 2 describes highest schooling attainment of NELS:88 respondents in all locations (column 2), and separately by the direction of immigration flows in their 8th grade CZs. Compare columns 4 and 6: native-born 8th-graders in high-immigration CZs stay in school longer than those in lower-immigration CZs. The difference is very small for high school graduation but the likelihood of getting post-secondary schooling increases more as local low-skilled immigration increases. This is consistent with the hypothesis that local natives distinguish themselves from low-skilled immigrants by attaining more education. Of course, Table 2's simple differences in means mask potential confounding factors and other explanations. The mean differences do not control for student demographics and backgrounds that surely influence schooling attainment. In addition, they do not account for potential local factors that both induce low-skilled immigration and raise the return to schooling of local natives, like a local positive shock to labor demand. Empirical specifications in the next section address both of those issues.

Specifically, I regress measures of individual educational attainment on local immigration flows and control variables that might influence schooling decisions and be incidentally correlated with immigration. The basic regression equation explaining individual human capital (H) investment is:

$$H_{i,s,c} = \alpha \Delta I_{c,1990} + \beta X_i + \Gamma W_c + \Lambda Z_s + e_{i,s,c}. \tag{6}$$

Human capital investment (H) of individual i is influenced by the immigration flow to i's 8th grade location (CZ c), which is measured by $\Delta I_{c,1990}$ (defined by Equation 5).[23] Individual characteristics like sex and race influence school decisions and might vary across

[23]Equation 6 is an empirical analog of $\delta(s)$ in Section 2, natives' human capital as a function of immigration.

locations, so I control for them in X_i (which also includes a constant term). In some specifications, X_i also includes mother's education, which is a strong predictor of schooling and might also be related to local immigration (say, if highly-educated mothers leave locations with high low-skilled immigrant flows). The vector W_c includes characteristics of the 8th grade CZ: region, population size, and metropolitan status. To control for local features that influence schooling decisions (other than recent immigration), I also control for the CZ's 1990 percent of adults with a college degree and the percent of adults without a high school degree. Local immigration may reduce school resources, so I control in some specifications for the percent of classmates in the NELS:88 respondent's 8th grade school who have limited proficiency in English (Z_s). My intention is to control for immigration's role in crowding-out natives from local schools, in order to focus on the effects of immigrants in the labor force.[24]

Studies using Census data tend to take decade-long differences to wipe out all long-term characteristics of states or MSAs. This strategy is not available to me, since the outcome variables in the NELS:88 pertain to a single cohort. However, the control variables in X_i, W_c, and Z_s should capture many of the potential schooling shifters that might also be correlated with local immigration flows. Indeed, some of the variables included are not available with Census data (e.g., school characteristics, mother's education for adult respondents). Still, there may be unobserved location-specific features that shift both immigration and natives' schooling decisions. Below I describe the instrumental variables strategy I undertake in response to that possibility.

In area-based studies of the effects of immigration on wages, there are always concerns about omitted variables bias. In particular, local labor demand shifters likely increase immigration and wages and may be unobserved in a regression. Similar bias may be present when associating educational attainment and local immigration, although the endogeneity story is less compelling than with wages. Nevertheless, there could be unobserved local traits that affect both immigration and human capital investment of local natives.

[24]The standard errors that I report are clustered at the 8th grade CZ level.

For example, current wage growth may be un-measured (or mis-measured), but it could yield both higher immigration and less educational attainment among natives by raising the opportunity cost of time in school. With such endogeneity in mind, I estimate specifications that instrument for recent immigration flows with origins of earlier local immigrants and nationwide immigration by origin. Bartel (1989) demonstrates that the strongest predictor of where U.S. immigrants choose to live is the prior presence of members of the same ethnic group. This is most true of less-educated immigrants, the focus of my study. The idea of using such behavior in an identification strategy comes from Altonji and Card (1991), and is employed frequently in the economics literature.

The specific instrument I use for immigration flows follows Smith (2010). Let c index CZs of residence and o denote an immigrant's region of origin. $I_{o,c,t}$ is the number of (low-skilled) immigrants from origin region o living in CZ c in Census year t. $I_{c,t}$ is the total number of immigrants living in CZ c (all origins), and $I_{o,-c,t}$ is the total number of immigrants from region o in CZs *other than* c. The instrument is:

$$\widetilde{I}_{c,1990} = \ln\left(\sum_{o} \frac{I_{o,c,1980}}{I_{c,1980}} I_{o,-c,1990}\right) - \ln\left(\sum_{o} \frac{I_{o,c,1970}}{I_{c,1970}} I_{o,-c,1980}\right) \tag{7}$$

The instrument identifies variation in immigration flows across CZs using nation-wide trends in immigration by origin ($I_{o,-c,1980}$ and $I_{o,-c,1990}$) and the origins of local immigrants in the previous period ($I_{o,c,1980}/I_{c,1980}$ and $I_{o,c,1970}/I_{c,1970}$).[25] A CZ would have a high predicted immigration flow ($\widetilde{I}_{c,1990}$) if it has a relatively large pre-existing share of immigrants from recent sending countries. Such variation is plausibly unrelated to contemporary (1990) economic conditions that motivate immigrants to settle locally and also motivate young native residents to invest in education.

Note that CZ differences in the instrument *do not* arise from pre-existing differences in immigration levels or growth. The instrument predicts higher immigration flows among CZs with relatively large shares of their immigrant populations from regions that subse-

[25]There are 16 origin regions. Table B.1 lists them. I assign people to origins based on their countries of birth in the Census.

quently sent many immigrants. Using region shares in the previous immigrant population normalizes by prior immigration levels and growth. For example, a CZ with very low immigration a decade ago may have a large predicted immigrant flow if a large share of its (small) earlier-period immigrant population was from a region that sent many immigrants later.

Table 3 shows that the instrument ($\widetilde{I}_{c,1990}$) is a strong predictor of immigration flows. The observations are NELS:88 respondents. The dependent variable is the actual immigration flow ($\Delta I_{c,1990}$) they experienced. In addition to the instrument $\widetilde{I}_{c,1990}$, all specifications include sex and race-ethnicity variables and characteristics of the respondent's CZ: indicators for urbanicity and region,[26] percent of the 1990 adult population with a bachelor's degree, and percent of the 1990 adult population with less than high school education. The local education distribution is meant to capture potential local traits other than immigration flows that shift human capital investment of locals. Some (second-stage) specifications below include mother's education and the percent of students in the respondent's school who have limited English capabilities, so columns 2 and 3 include these variables. In all three specifications of Table 3, predicted immigration flows are strongly associated with actual flows between 1980 and 1990. The F-statistics for the instrument's coefficients equaling zero are above 100: this is a strong instrument.

In the next section, I use the instrument $\widetilde{I}_{c,1990}$ to identify increases in natives' final educational attainment due to local immigration. In addition, I investigate various channels through which this effect may arise. For example, local immigration might change attitudes toward school and work, especially if local native youth believe they will need to compete with immigrants for future jobs. Consequently, I associate local immigration with attitudes and expectations of natives in school: whether they think education is important for future jobs and how much education they expect to attain. Native students may also attempt to differentiate themselves from abundant immigrant labor by trying

[26]The urbanicity indicators are descriptions of CZs from Tolbert and Sizer (1996). There are 6 categories based on CZ population (in order of increasing population): small town, small urban, larger urban, small metro, medium metro, and major metro. The largest three size categories indicate CZs that include an MSA. The four region categories are South, Northeast, Midwest, and West.

harder in school. I measure such efforts with student responses about the frequency of their school attendance and how many hours they spend doing homework.

Native students may also choose their school curricula conditional on their expected work environment, which is influenced by expectations about immigration. I observe whether students took an Advanced Placement class as a proxy for effort in academics and the intention of continuing education past high school. I infer the opposite intention for students taking vocational classes. Increased efforts at school should also translate into higher grades and standardized test scores, so I use these as outcome variables as well.

Finally, the NELS:88 reports early-career job characteristics of its respondents. If natives' human capital investments are specifically tailored to enhancing their comparative advantages relative to immigrants (as in Peri and Sparber 2009), then natives' jobs should involve more communication tasks. To infer such investments, I measure the extent to which NELS:88 respondents read, write, and use computers on the job (in particular, for language-oriented tasks like word processing and writing e-mail). Respondents also report the extent to which they estimate the size or weight of objects; I take this as a more-manual, less-verbal task type that natives would undertake less to the extent they have differentiated themselves from immigrant workers.

The third and fourth panels of Table 2 describe NELS:88 respondents' attitudes and behaviors in school.[27] Students in high-immigration CZs think they are more likely to go to college, do more homework, take more AP classes, and take fewer vocational classes. These could measure the effect of immigration on natives' choices or other features of the CZs (such as city size). From the lower panels of Table 2, native-born workers from high-immigration origins tend to read somewhat more on the job, use computers more frequently, and use fewer manual tasks. These mean differences are consistent with natives differentiating their skills from local immigrants, but they could also reflect other

[27]Table 2 only includes (the subsample of) fourth follow-up sample members when describing educational attainment by age 26 and job characteristics. But the table retains larger sample sizes when describing characteristics that are set in secondary school (e.g., expectations in the 10th grade).

features of CZs that are incidentally correlated with low-skilled immigration. I control for such potential confounding factors in specifications below.

5 Results about immigration and natives' school attainment

In this section, I describe evidence that local natives respond to less-educated immigrant flows by increasing their educational attainment. Natives are both more likely to complete high school and also to acquire post-secondary schooling. These are consistent with the desire to avoid labor market competition with immigrants who have relatively little education.

Table 4 illustrates the relationship between local immigration and the likelihood that a local native-born student will complete high school. The dependent variable is an indicator for completing high school, where a GED credential does not count as completion.[28] Respondents could have completed high school at any time before the final NELS:88 interview in 2000 (when respondents were mostly 26 years old). The first column regresses this variable on the measure of low-skilled immigration to the respondent's 8th grade CZ, controls for respondent's sex and race/ethnicity, and controls for 8th grade CZ characteristics: urbanicity, region, and pre-existing education distribution. The standard errors reported in this and subsequent tables are clustered at the 8th grade CZ level. The OLS specification in column 1 reveals a positive coefficient on immigration that is not statistically distinguishable from zero. Women and Asian and white students (the omitted category) are most likely to complete high school.

Mother's education is a strong predictor of schooling attainment. Although the specifications already control for the educational distribution of adults in the CZ, it is still possible that something other than immigration about high-immigration CZs induces children to get more education. For example, growing labor markets may quickly attract

[28] Evidence in Heckman, Humphries, and Mader (2010) that GED recipients do not earn a positive return in the labor market from their GED credential motivates me to categorize them as high school dropouts. However, I also ran specifications that treat GED recipients as high school completers, and obtained similar results.

highly-educated workers,[29] whose children tend to get plenty of education as well. The control for mother's education should capture such an effect directly. Column 2 of Table 4 includes a control for mother's years of schooling. The control predicts higher schooling among respondents and reduces the coefficient on immigration somewhat, though it remains positive and insignificant.

Betts (1998) notes that immigration may decrease educational attainment of natives, as immigrant children use up resources at the school or school district level. Such an effect would reduce the quality of school and thereby its return to natives. Some specifications in Betts (1998) control for state-level school resources (pupil-teacher ratio), but he suggests that school-level controls would be preferable in testing the effect of immigration on natives' educational attainment.

The specification in column 3 of Table 4 takes up that suggestion in a simple way. School administrators of NELS:88 schools were asked how many students in their school's 8th grade cohort had limited English proficiency, which I interpret as a proxy for immigrants' needs at the school level. Column 3's specification includes indicator variables for 11-20 percent, 21-30 percent, and 31 and higher percent 8th-graders with limited English proficiency. The omitted category is 10 percent or less. The inclusion of these controls means that the regression compares students in schools facing similar resource needs from immigrants. In particular, these controls should help account for the potential that parents in high-immigration areas choose their children's schools to reduce exposure to immigrants.[30] In this specification, the coefficients on limited-English classmate controls are not statistically significant and do not affect the coefficient on local immigration.

So far, the results in Columns 1 through 3 imply that native-born 8th graders in higher-immigration CZs are slightly more likely to graduate from high school, but the effects are statistically insignificant. However, those specifications take local immigration flows to be exogenous with respect to other determinants of school attainment. Columns 4 through

[29] Wozniak (2010) shows that highly-educated workers are more likely to move in response to local labor market conditions than less-educated workers.

[30] Betts and Fairlie (2003) report evidence that parents in higher-immigration areas are more likely to send their children to private school.

6 of Table 4 show results from two-stage least squares specifications that exploit variation in local immigration flows induced by pre-existing immigration patterns ($\widetilde{I}_{c,1990}$). These specifications reveal a significant positive effect of local immigration on natives' completion of high school that is robust to controls for mother's education and 8th grade school characteristics. The Column 6 specification implies that if the local immigration flow increases by 10 percent, the high school graduation rate among natives should increase by about 0.337 percentage points. This seems like a small effect. However, the high school graduation rate is an important social metric that has been stubbornly low in the U.S., and a 10 percent increase in a local immigration flow is commonplace: the standard deviation of the immigration flow across NELS:88 respondents is about 45 percentage points.

Table 5 repeats specifications from the previous table using a new dependent variable: an indicator for the respondent attending any post-secondary schooling. Specifically, the dependent variable equals one if the NELS:88 respondent had ever attended "college, university, or vocational, technical or trade school for academic credit" (by the time they were 26 years old). As with high school completion, OLS specifications in columns 1 through 3 imply that local immigration slightly increases natives' post-secondary attendance, but the effect is statistically insignificant. The instrumental variables specifications, however, reveal strong positive effects. Column 4 implies that a 10 percent increase in local immigration flow raises the college-going rate among natives by 1.4 percentage points. The controls in columns 5 and 6 for mother's education and for classmates' limited English proficiency lower the effect somewhat, but it remains statistically and economically significant. The effect on post-secondary attendance is larger than the effect on high school completion, implying that native-born high school graduates (not just dropouts) are particularly affected by local immigration.

Many students start post-secondary education programs but never finish them. It is not clear that just starting college would translate into better labor market outcomes for students. Table 6 documents the relationship between immigration in 8th grade and the likelihood that a native-born student acquires a post-secondary credential. The depen-

dent variable is an indicator for earning (by age 26) any post-secondary degree, including associate's and bachelor's degrees. The results here imply that immigration induces local natives not just to start post-secondary school but also to finish. OLS specifications of the first three columns show small positive relationships, but the IV estimates are statistically significant. They are smaller than the effects in the previous table about attendance only, which is not surprising if immigration induces marginal college-goers to stay in school after getting the high school diploma. The effects in Table 6 are also somewhat noisier than previous tables' estimates. However, it is significant that immigration induces local natives to complete post-secondary educational programs, which yield high returns in the labor market.

Columns 3 and 6 of Table 6 imply that NELS:88 students with more limited-English classmates in 8th grade are less likely to finish a post-secondary degree program. This is consistent with the crowd-out hypothesis associated with Betts (1998). Less post-secondary education may follow a lower quality secondary education caused by immigrants competing for resources.

6 Results about immigration and natives' efforts and success at school

This section describes the relationship between local immigration flows and students' efforts in secondary school. I exploit the rich information about students' experiences in the NELS:88 to illuminate mechanisms behind immigration's role in natives' education attainment. The evidence here supports the hypothesis in Section 2 that $\delta'(s) > 0$: that is, local immigration induces native-born youth to increase their human capital. Overall, native-born students in relatively high-immigration CZs appear to invest more in academics, although their homework hours do not increase.

The NELS:88 includes a variety of questions about specific attitudes and behaviors while students are in secondary school. Local immigration might change attitudes to-

ward school and work, especially if local native youth believe they will need to compete with immigrants for future jobs. To measure such attitudes, I use responses to three questions in the 10th grade survey. The first is an indicator that the student strongly agrees that education is important to get a job later, which might be more likely among natives who anticipate future competition in labor markets for high school dropouts. The other two responses describe students' expectations of future schooling. They are indicators for students being sure they will graduate from high school and sure they will continue education after high school.

Table 7 displays results from two-stage least squares regressions with various specifications and dependent variables. Each cell in the table reports the coefficient (and standard error) on the 8th grade CZ low-skilled immigration flow. Each row describes a different dependent variable, and columns contain different specifications. The first three columns reflect the sample of all respondents with non-missing data. These are larger samples than used in the previous section, since this section's samples include both respondents kept and dropped in subsampling for the final follow-up survey. Columns 4 through 6 select only NELS:88 respondents whose mothers had no more than 12 years of schooling. Children of less-educated parents are likely to compete in labor markets with less-educated immigrants, so their behaviors are of particular interest.

The first panel of Table 7 reports the effects of local immigration flows on attitudes and expectations of native-born 10th-graders. The first row includes little evidence that immigration increases the extent to which 10th grade natives think education is important for their careers. The first column's coefficient (0.032) reflects a baseline specification that controls for local immigration, individual sex and race/ethnicity, and 8th grade CZ controls. The coefficient is sizable but not statistically significant. The second column adds a control for mother's education, and the third column adds controls for English proficiency in the respondent's 8th grade school. Columns 4 through 6 refer to the subsample of respondents whose mothers have 12 or fewer years of schooling, where the effect of immigration on natives' attitudes toward education and careers is very small.

The second results row in Table 7 shows in similar specifications that increased local immigration does not induce 10th graders to increase their expectations of completing high school. However, the third row implies that students experiencing high local immigration are more likely to expect to continue their education after high school. This is true with different specifications that control for family background and early school environment, and in both the full sample and those with less-educated parents. It is consistent with the actual post-secondary attainment increases reported in the previous section.

Native students may attempt to differentiate themselves from abundant immigrant labor by trying harder in school. To measure such behavior, I collect information about school attendance and hours spent on homework outside of school. The 8th grade and 10th grade surveys ask respondents how many days they were absent from school and how frequently they skipped classes. Using the final follow-up wave of NELS:88 (age 26), I regress an indicator for graduating from high school on indicator variables for absence and skipping frequencies. For each respondent in the full sample, I predict a graduation probability using their responses about absences and skipping class. I use this as a school attendance composite variable in the analysis. I also use students' self-reported hours of out-of-school homework per week in the 10th grade.

Table 7 shows that low-skilled immigration tends to increase school attendance among native-born students. If this is the sum of both the (negative) effect of fellow immigrant students–working through school resources–and the (positive) effect of immigrants in the labor market, then it is particularly strong evidence that natives increase their human capital investments in the face of competition with immigrants. The finding in columns 4 through 6 that the effect is somewhat stronger among natives with less-educated parents lends further weight to this interpretation. Controls for limited-English proficiency among 8th grade schoolmates (columns 3 and 6) do not change the result. On the other hand, there is no evidence that native-born students increase their homework hours in the midst of immigration flows (if anything, they do less homework).

Native-born students may also choose their school curricula conditional on their ex-

pected work environment. The NELS:88 identifies students who took Advanced Placement (AP) classes, which are academically rigorous and useful in transitioning to college. The surveys also ask students whether they have taken a vocational class. I hypothesize that relatively large local flows of immigrants with little formal schooling would raise the labor market return to AP classes and lower the labor market return to vocational class. The sixth and seventh rows in Table 7 confirm this hypothesis. Native-born students in higher-immigration CZs are more likely to take AP classes and less likely to take vocational classes. The effects are stronger among students with less-educated parents (columns 4 through 6).

To measure success in school–a partial indicator of human capital investment–I collect information about grades and test scores. NELS:88 students reported their grades in the first follow-up survey (10th grade for most of them) in math, English, history, and science classes. Their responses for each subject were "mostly As", "half A and half B", "mostly Bs", etc. and also "not taking subject." With the final follow-up sample of 26-year-olds, I regressed an indicator for graduating from high school on indicators for each response about grades and used the resulting coefficient estimates to predict graduation conditional on grades for each student. This is a grades composite to measure academic success in high school. The eighth row in Table 7 shows a positive effect of immigration on native-born students' grades, and the effect is very consistent across specifications.

Finally, I use measures of test scores in 8th and 12th grades to infer schooling investments. In each grade, the NELS:88 reported standardized test scores in reading and math. I aggregate test score information for each grade by forming an earnings prediction conditional on a student's reading and math scores. That is, I measure labor market earnings in years after each student completed schooling (up to the final follow-up survey when respondents were around 26 years old). I regress log annual earnings on 8th or 12th grade reading and math test scores; indicators for state, year, sex, and race/ethnicity; indicators for completed schooling levels; and a quadratic in years of labor market experience. The test score composite for each student is predicted log earnings given that student's test

scores and other characteristics held fixed across all students (a white male high school graduate from New York with no work experience in 2000). I make two predictions separately: one with 8th grade test scores and another with 12th grade test scores.

The final two rows of results in Table 7 display the effect of low-skilled immigration to the CZ on the test score indexes of native-born students. The effects are uniformly positive and statistically significant, using alternative controls and for the subsample of students with less-educated parents (columns 4 through 6). A coefficient around 0.8 implies that a 50 percent increase in low-skilled immigration flow to the CZ causes natives' test scores to increase by enough to shift predicted earnings up by about 0.3 percent. This is a small change but does reflect some increased performance in school related to expectations of low-skilled immigration to the labor market. The test score increases occur in both 8th and 12th grades to about the same extent.

The results about test scores are related to a previous literature that mostly emphasizes how native-born students are affected by immigrants in their own school. The focus is on the school quality effect of immigration rather than the effect of labor market expectations. For example, Diette and Oyelere (2012) show that immigration flows to North Carolina affected test scores of natives. Interestingly, low-ability natives increased their scores while high-ability natives decreased theirs, which is consistent with the dual mechanisms affecting natives differently by pre-existing ability. Perhaps native students who are likely to drop-out of high school ("low-ability" in Diette and Oyelere 2012) are more likely to increase their motivation and performance in the midst of expected labor market competition. On the other hand, higher-ability natives appear more affected by a reallocation of schooling resources and see their test scores fall.

7 Results about immigration and natives' early-career jobs

This section describes another way that native-born residents change their human capital investments in response to low-skilled immigration: augmenting their comparative ad-

vantage in communication skills. Peri and Sparber (2009) document evidence of native-born workers adjusting their relative task supplies to the labor market in response to immigration. Their paper analyzes a general equilibrium model in which less-educated workers supply both "communication" and "manual" tasks. Immigrants with relatively little education have lower verbal and communication skills, so immigration increases the relative supply of manual tasks to the local economy. The result is a lower relative wage paid for manual tasks, which induces native-born workers to exploit their comparative advantage in the communication task and supply more of it. In this way, less-educated native workers shield themselves from wage competition with less-educated immigrants, and the process attenuates the effect of immigration shocks on natives' wages. Peri and Sparber (2009) confirm the predictions from their model using 1960 to 2000 Census data describing states.

The NELS:88 allows me to provide complementary evidence that supports their framework. Instead of inferring tasks from workers' occupations as in Peri and Sparber (2009), I observe direct responses about tasks that workers perform on the job. The NELS:88 asks respondents in the 2000 survey (when they were about 26 years old) how frequently on their most recent jobs they wrote or read something, used a computer, and measured or estimated the size or weight of objects. I interpret reading and writing and e-mail, word processing, and Internet computer use as communication tasks. I interpret the estimation of sizes and weights of objects as manual tasks (like spreading mulch on a landscaping job).

To get a sense for what responses about job tasks imply, Table B.2 categorizes specific occupations by task responses. The first column shows the percent of NELS:88 respondents in each occupation who read letters and memos "a lot" at work, and the second column shows the percent in each occupation who estimate the size and weight of objects "a lot." The third column takes the ratio of the first two columns, a measure of relative communication-oriented tasks in each occupation. Legal professionals are clearly intensive employers of communication tasks. The occupations near the bottom of the table in-

clude manual jobs (e.g., cooks, laborers, farm laborers), consistent with my interpretation of the "estimate size and weight" responses as implying manual tasks. These occupations are also common among immigrant workers. A native-born worker wanting to avoid labor market competition with low-skilled immigrants would prepare for other jobs, where he would probably "estimate size and weight" less and "read letters and memos" more.

My findings agree with Peri and Sparber's: native-born workers in the midst of less-skilled immigration tend to supply relatively more communication tasks. Table 8 assesses the relationship between early immigration exposure and job characteristics in the early careers of native workers. The NELS:88 asked respondents about job conditions where they work at the time of the 2000 survey or their most recent job if not currently working. Workers responded "never", "occasionally", or "a lot" to multiple prompts about tasks they did at work. I generate indicators for workers doing "a lot" of "read letters, memos, or reports", "write letters, memos, or reports", "use computer", "word processing", "send and receive e-mail", "search the Internet", and "measure or estimate the size or weight of objects." The specifications in Table 8 are two-stage least squares and control for respondents' sex and race/ethnicity and characteristics of the CZ where they live (and perform their work tasks) in 2000. The coefficients on immigration exposure in regressions predicting reading and writing tasks (the first two rows of results in Table 8) are uniformly positive. There is not much statistical precision, but the results are consistent with low-skilled immigration inducing natives to invest more in communication skills and use them at work.

The next panel of Table 8 is labeled *Computer and communication tasks*. There is not a consistent effect of immigration on computer use, but natives originating in CZs with more immigration tend to use word processing, e-mail, and the Internet more frequently. Effects are somewhat noisy for the subsample of natives with less-educated parents (columns 4 through 6), but the coefficients are somewhat large and statistically significant for Internet use. The last row of the table investigates the effect of immigration exposure on manual tasks at work. The effect is negative in all specifications and both samples. Over-

all, the results are consistent with Peri and Sparber's (2009) hypothesis that natives respond to low-skilled immigration by augmenting communication skills at the expense of manual skills.[31]

My findings about immigration and job tasks are related to previous research showing that manufacturing firms in cities experiencing large low-skilled immigration waves are less likely to invest in automation machinery (Lewis 2011), and firms near higher skill supplies are more likely to adopt personal computers (Beaudry, Doms, and Lewis 2010). In light of this previous research about business firms, it would appear that workers overall are *less* likely to use computers in cities with many low-skilled immigrants, but I find that native-born workers experiencing low-skilled immigration waves early in life use computers more frequently at work.. The increased early-career computer use I observe is probably due more to individual natives' human capital investment and occupational choices, than to local firms' production decisions. Both workers and firms are choosing skill and task mixes in production. I have focused on choices of workers to invest in particular tasks, and I believe this is appropriate given that the behavior I observe is in response to immigration waves early in life. However, the effects I estimate are probably also partially due to changes in firms' productive processes.

8 Conclusion

I show that U.S. native-born respondents to the National Education Longitudinal Study of 1988 increased their human capital when their local labor markets experienced inflows of low-skilled immigrants. In particular, they increased high school attendance, got higher grades, and achieved higher test scores. They completed more years and credentials at school. In addition, young native-born workers differentiated themselves from low-

[31] I also investigated whether immigration affected native-born respondents' job training activities. The NELS:88 asks whether respondents ever participated in a job training program, and also whether they got training in order to improve basic communication skills. I regressed indicators for training and communication-specific training on immigration flows in two-stage least squares specifications analogous to those in Table 8. The coefficients on the 8th grade immigration flow variable were positive but statistically insignificant.

skilled immigrant workers by taking jobs that involve more communication tasks, rather than manual tasks. These results use instrumental variables to account for endogeneity of local immigration flows, and control for potentially confounding environmental factors like family background, peers at school, and local labor market characteristics.

While much of the debate about immigration policy tends to focus on potential costs to pre-existing residents, I emphasize a benefit. The increased human capital investments I observe make up a positive effect of immigration, as long as native-born youth tend to under-invest in education. They probably do. Human capital spillovers are likely positive. In addition, high school dropout rates are very high, even though the returns to schooling are large, in terms of labor market success and also non-pecuniary benefits like health (see Oreopoulos 2007).

My findings also add to the debate about what effect immigration has on natives' wages. Earlier research produced large estimates of the elasticity of substitution between foreign-born and native-born workers (e.g., Borjas, Grogger, and Hanson 2011). I demonstrate that those estimates are upward-biased when native-born workers augment their human capital in the face of labor market competition from foreign-born workers. My empirical work implies that they do. So, the degree of substitutability between immigrants and natives in the labor market is probably smaller than previously-estimated. This implies lower effects of immigration on natives' wages, which is consistent with more-direct evidence of immigration effects from area-based studies (e.g., Card 2005).

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9 Tables

Table 1: Summary Statistics of Immigration to Commuting Zones, 1990 U.S. Census

	(1) Mean [St.Dev.]	(2) 1st ptile	(3) 10th ptile	(4) Median	(5) 90th ptile	(6) 99th ptile
% Immigrants	2.7	.2	.5	1.4	5.7	22.1
in CZ population	[3.8]					
% Low-education Immigrants	1.9	.1	.3	.9	4.7	18.6
in CZ population	[3]					
% Low-education	64	31.1	47.7	63	84	94.1
in CZ's Immigrant population	[13.9]					
% change from 1980 to 1990 in CZ's	-9.6	-74.7	-56.6	-23.6	60.8	199.3
Low-education Immigrants	[52.3]					

NOTES: Data from 1990 U.S. Census (IPUMS: Ruggles, et al. (2010)). CZ means Commuting Zone, a group of counties that make up an integrated local labor market. Summary statistics describe the distribution across the 741 CZs in the U.S. Immigrants are those born outside U.S. states or territories. Low-education means high school or less. Population counts reflect population weights and include children (young children all have low education).

Table 2: Summary Statistics for NELS:88 Respondents, by 8th Grade Immigration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		All respondents		8th grade Immigration growth < 0		8th grade Immigration growth ≥ 0	
	N	Mean	(St. Err.)	Mean	(St. Err.)	Mean	(St. Err.)
Personal characteristics							
Female	19,280	.5045	(.0036)	.5047	(.0047)	.5043	(.0056)
Black	19,280	.1335	(.0024)	.1295	(.0032)	.139	(.0038)
Hispanic	19,280	.0856	(.002)	.034	(.0017)	.1572	(.0041)
Asian	19,280	.0158	(9.0e-04)	.0133	(.0011)	.0193	(.0015)
American Indian	19,280	.0123	(7.9e-04)	.0128	(.0011)	.0116	(.0012)
Mother's education (years)	19,280	13.25	(.0153)	13.15	(.0196)	13.38	(.0244)
Educational attainment by age 26							
HS graduate (no GEDs)	9,540	.9232	(.0027)	.923	(.0035)	.9235	(.0043)
Ever attended PSE	9,540	.7896	(.0042)	.7714	(.0055)	.8178	(.0063)
PSE credential	9,540	.4831	(.0051)	.4751	(.0066)	.4956	(.0082)
BA or more education	9,540	.3293	(.0048)	.3173	(.0061)	.3479	(.0078)
Attitudes in school							
1990: Educ. Important for Career	12,940	.6207	(.0043)	.6168	(.0055)	.6268	(.0068)
1990: Sure to Grad. High School	13,830	.8783	(.0028)	.8826	(.0035)	.8719	(.0045)
1990: Sure to Continue Educ. after HS	13,790	.6361	(.0041)	.6173	(.0054)	.6637	(.0063)
Behaviors in school							
School attendance composite	19,280	.8996	(7.2e-04)	.9034	(9.3e-04)	.8943	(.0011)
Homework hours (out of school)	13,840	6.585	(.1269)	6.164	(.157)	7.203	(.2116)
Took AP class	12,460	.3835	(.0044)	.3493	(.0055)	.4347	(.007)
Took vocational class	12,440	.1465	(.0032)	.1656	(.0043)	.1178	(.0046)
Grades composite	19,280	.8614	(.001)	.8643	(.0013)	.8575	(.0016)
8th grade test score index	18,370	1,000.7	(.0308)	1,000.6	(.0396)	1,000.8	(.0487)
12th grade test score index	10,810	1,001.4	(.0403)	1,001.4	(.0512)	1,001.5	(.0655)
Early career job: Communication tasks (general)							
Read letters, memos, or reports	8,160	.4757	(.0055)	.4648	(.0071)	.4927	(.0089)
Write letters, memos, or reports	8,160	.3139	(.0051)	.3111	(.0066)	.3184	(.0083)
Early career job: Computer and communication tasks							
Use a computer	8,170	.675	(.0052)	.6589	(.0067)	.7004	(.0081)
Use word processing	6,580	.4707	(.0062)	.4504	(.0079)	.5008	(.0097)
Use e-mail	6,580	.5198	(.0062)	.5003	(.008)	.5487	(.0097)
Use Internet	6,580	.3446	(.0059)	.3166	(.0074)	.3862	(.0095)
Early career job: Manual tasks							
Measure size or weight of objects	8,160	.2921	(.005)	.3052	(.0065)	.2715	(.0079)

NOTES: Data from the NELS:88. Sample sizes rounded to the nearest 10 for confidentiality restrictions. Educational attainment and work variables includes only respondents in the final 2000 follow-up survey. HS means high school, GED means General Education Development credential, PSE means post-secondary education, and BA means bachelors degree. Columns 1 and 2 describe the full sample. Columns 3 and 4 describe only respondents whose 8th grade Commuting Zones experienced reductions in their low-skilled immigrant populations between 1980 and 1990. Columns 5 and 6 describe only respondents whose 8th grade Commuting Zones experienced increases in their low-skilled immigrant populations between 1980 and 1990.

Table 3: First-Stage Results: 1980 to 1990 Immigration and Predictions Based on Lagged Immigration by Origin

	(1)	(2)	(3)
Predicted Immigration (IV)	.621***	.621***	.621***
	(.0586)	(.0585)	(.0576)
Female	-.00454	-.00454	-.00405
	(.00581)	(.00581)	(.00578)
Black	-.0475**	-.0475**	-.0529**
	(.0239)	(.0239)	(.0239)
Hispanic	.00109	.00111	-.00206
	(.0289)	(.0293)	(.0289)
Asian	-.0532	-.0532	-.0593
	(.0403)	(.0403)	(.0408)
American Indian	-.031	-.031	-.00585
	(.0349)	(.0352)	(.0313)
Mother's education		.0000124	.0000304
		(.00225)	(.0023)
11-20 pct. Limited English			.094
			(.0644)
21-30 pct. Limited English			-.0151
			(.0485)
31+ pct. Limited English			-.103*
			(.0608)
Observations	9230	9230	9230
R-squared	0.613	0.613	0.616
First stage F	112.4	112.7	116.4

NOTES: ***p<0.01 **p<0.05 *p<0.1. Data from the NELS:88. Dependent variable is a 1990 measure of immigration to the respondent's 8th grade Commuting Zone (CZ). All models include a constant and characteristics of 8th grade CZ: % adult population with a BA, % population without a high school diploma, and indicators for urbanicity (5 of them) and region (3 of them). Pct. Limited English refers to the percent of students in the respondent's 8th grade school cohort who have limited English proficiency. Standard errors clustered at 8th grade CZ level. Sample sizes rounded to the nearest 10 for confidentiality restrictions.

Table 4: Local Immigration and Schooling of Natives: Completing High School (excluding GEDs)

	(1)	(2)	(3)	(4)	(5)	(6)
		OLS			2SLS	
CZ Immigration 1990	.0121	.00779	.00815	.0493***	.0337**	.0337**
	(.0134)	(.0126)	(.0126)	(.019)	(.0162)	(.0161)
Female	.0128**	.0171***	.0171***	.013**	.0172***	.0172***
	(.00545)	(.0054)	(.00541)	(.00545)	(.00539)	(.0054)
Black	-.0358***	-.0263**	-.0259**	-.0331***	-.0244**	-.024**
	(.011)	(.0104)	(.0105)	(.0111)	(.0105)	(.0105)
Hispanic	-.0582***	-.0256*	-.0258*	-.0637***	-.0295**	-.0295**
	(.0149)	(.0136)	(.014)	(.0144)	(.0131)	(.0135)
Asian	.0392***	.0388***	.0391***	.0412***	.0401***	.0406***
	(.0129)	(.0137)	(.014)	(.0132)	(.0139)	(.0142)
American Indian	-.101***	-.0772**	-.0831**	-.099***	-.0761**	-.0826**
	(.0333)	(.0312)	(.0321)	(.0338)	(.0315)	(.0323)
Mother's education		.0264***	.0264***		.0263***	.0263***
		(.0017)	(.00169)		(.00169)	(.00168)
11-20 pct. Limited English			-.000783			-.00344
			(.0175)			(.0173)
21-30 pct. Limited English			-.003			-.00298
			(.0268)			(.0261)
31+ pct. Limited English			.0235			.0258
			(.0254)			(.0267)
Observations	9230	9230	9230	9230	9230	9230
R-squared	0.016	0.056	0.056	0.014	0.055	0.055
First stage F				112.4	112.7	116.4

NOTES: ***p<0.01 **p<0.05 *p<0.1. Data from the NELS:88. Dependent variable is an indicator for graduating from high school (excluding GEDs). All models include a constant and characteristics of 8th grade CZ: % adult population with a BA, % population without a high school diploma, and indicators for urbanicity (5 of them) and region (3 of them). Pct. Limited English refers to the percent of students in the respondent's 8th grade school cohort who have limited English proficiency. Columns 1 through 3 show OLS results. Columns 4 through 6 use predictions of low-skilled immigration to the CZ from previous immigrant populations to instrument for contemporary immigration. First stage F statistic is the Kleibergen-Paap rk Wald F statistic for weak instruments. Standard errors clustered at 8th grade CZ level. Sample sizes rounded to the nearest 10 for confidentiality restrictions.

Table 5: Local Immigration and Schooling of Natives: Attending Post-Secondary School

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS			2SLS		
CZ Immigration 1990	.0286	.0188	.02	.139***	.104***	.104***
	(.0206)	(.0175)	(.0176)	(.0351)	(.0271)	(.027)
Female	.0495***	.0593***	.0592***	.05***	.0596***	.0595***
	(.00907)	(.00865)	(.00866)	(.00914)	(.0087)	(.00871)
Black	-.053***	-.0315**	-.0297**	-.045***	-.0255*	-.0232*
	(.0152)	(.0129)	(.0127)	(.0156)	(.0132)	(.0129)
Hispanic	-.0629***	.0106	.0155	-.0791***	-.00236	.00308
	(.0224)	(.0195)	(.0199)	(.0213)	(.019)	(.0195)
Asian	.0469*	.0459*	.0492*	.0527*	.0504*	.0543*
	(.0272)	(.0278)	(.0293)	(.0273)	(.0277)	(.0292)
American Indian	-.185***	-.132***	-.134***	-.18***	-.128***	-.132***
	(.0516)	(.0453)	(.045)	(.054)	(.0471)	(.0461)
Mother's education		.0594***	.0592***		.0591***	.0589***
		(.00254)	(.00256)		(.00256)	(.00258)
11-20 pct. Limited English			-.0334			-.0422
			(.0295)			(.0289)
21-30 pct. Limited English			-.0372			-.0371
			(.0512)			(.0487)
31+ pct. Limited English			.00835			.0162
			(.0527)			(.055)
Observations	9230	9230	9230	9230	9230	9230
R-squared	0.027	0.115	0.115	0.019	0.110	0.111
First stage F				112.4	112.7	116.4

NOTES: ***p<0.01 **p<0.05 *p<0.1. Data from the NELS:88. Dependent variable is an indicator for ever attending post-secondary school. All models include a constant and characteristics of 8th grade CZ: % adult population with a BA, % population without a high school diploma, and indicators for urbanicity (5 of them) and region (3 of them). Pct. Limited English refers to the percent of students in the respondent's 8th grade school cohort who have limited English proficiency. Columns 1 through 3 show OLS results. Columns 4 through 6 use predictions of low-skilled immigration to the CZ from previous immigrant populations to instrument for contemporary immigration. First stage F statistic is the Kleibergen-Paap rk Wald F statistic for weak instruments. Standard errors clustered at 8th grade CZ level. Sample sizes rounded to the nearest 10 for confidentiality restrictions.

Table 6: Local Immigration and Schooling of Natives: Earning a Post-Secondary Credential

	(1)	(2)	(3)	(4)	(5)	(6)
		OLS			2SLS	
CZ Immigration 1990	.0293	.0182	.0184	.1**	.0603*	.0609*
	(.0248)	(.021)	(.0212)	(.0462)	(.0351)	(.0352)
Female	.075***	.0861***	.0862***	.0753***	.0862***	.0863***
	(.0103)	(.00956)	(.00955)	(.0103)	(.00956)	(.00955)
Black	-.126***	-.102***	-.101***	-.121***	-.0986***	-.0976***
	(.02)	(.0187)	(.0185)	(.0203)	(.0188)	(.0186)
Hispanic	-.177***	-.0941***	-.0911***	-.188***	-.101***	-.0974***
	(.0211)	(.0182)	(.0184)	(.0209)	(.0185)	(.0185)
Asian	-.0595	-.0607*	-.0592*	-.0558	-.0584*	-.0566
	(.0371)	(.0355)	(.0353)	(.0362)	(.0349)	(.0347)
American Indian	-.262***	-.202***	-.184***	-.259***	-.2***	-.184***
	(.0319)	(.0284)	(.0299)	(.0316)	(.0279)	(.0296)
Mother's education		.0674***	.0671***		.0672***	.0669***
		(.00242)	(.00241)		(.00243)	(.00241)
11-20 pct. Limited English			-.035			-.0394*
			(.0237)			(.0231)
21-30 pct. Limited English			.00882			.00885
			(.0497)			(.048)
31+ pct. Limited English			-.0688**			-.0649**
			(.0338)			(.0331)
Observations	9230	9230	9230	9230	9230	9230
R-squared	0.041	0.116	0.116	0.039	0.115	0.115
First stage F				112.4	112.7	116.4

NOTES: ***p<0.01 **p<0.05 *p<0.1. Data from the NELS:88. Dependent variable is an indicator for getting a post-secondary credential (certificate/license, AA, BA, MA, or professional degree). All models include a constant and characteristics of 8th grade CZ: % adult population with a BA, % population without a high school diploma, and indicators for urbanicity (5 of them) and region (3 of them). Pct. Limited English refers to the percent of students in the respondent's 8th grade school cohort who have limited English proficiency. Columns 1 through 3 show OLS results. Columns 4 through 6 use predictions of low-skilled immigration to the CZ from previous immigrant populations to instrument for contemporary immigration. First stage F statistic is the Kleibergen-Paap rk Wald F statistic for weak instruments. Standard errors clustered at 8th grade CZ level. Sample sizes rounded to the nearest 10 for confidentiality restrictions.

Table 7: Immigration and Natives' Efforts at School

	(1)	(2)	(3)	(4)	(5)	(6)
	All respondents			Mother had high school or less		
		Control for Mother's Education (Years)	Control for Grade 8 % Limited English		Control for Mother's Education (Years)	Control for Grade 8 % Limited English
Attitudes in school						
1990: Educ. Important for Career	.032	.0175	.0278	-.0029	-.0032	-.0049
	(.0248)	(.0252)	(.0247)	(.0395)	(.0396)	(.0395)
1990: Sure to Grad. High School	-.0056	-.0183	-.0081	-.0242	-.0264	-.0206
	(.0165)	(.0166)	(.0161)	(.0277)	(.0276)	(.0268)
1990: Sure to Continue Educ. after HS	.0955***	.0627**	.0924***	.077*	.0727*	.0771*
	(.0326)	(.0256)	(.0326)	(.041)	(.0402)	(.0422)
Behaviors in school						
School attendance composite	.0107*	.0093	.0114*	.0159*	.0161**	.0162*
	(.0063)	(.0059)	(.0063)	(.0085)	(.0082)	(.0085)
Homework hours (out of school)	-.8921	-.8947	-.7072	-1.417	-1.42	-1.119
	(1.127)	(1.119)	(1.13)	(1.604)	(1.602)	(1.63)
Took AP class	.1152***	.086***	.1125***	.1469***	.1461***	.1414***
	(.0351)	(.0303)	(.035)	(.0379)	(.0377)	(.0385)
Took vocational class	-.1559***	-.142***	-.1584***	-.2415***	-.2407***	-.2456***
	(.0402)	(.0378)	(.0395)	(.0533)	(.0533)	(.0544)
Grades composite	.033***	.0361***	.034***	.0344***	.0347***	.0367***
	(.0111)	(.0106)	(.0115)	(.0119)	(.0118)	(.0123)
8th grade test score index	.8832**	.5317**	.8604**	.8263***	.8399***	.8423***
	(.3646)	(.2703)	(.3655)	(.2913)	(.2731)	(.2898)
12th grade test score index	.9859**	.7664**	.9753**	.8715*	.8199*	.8731*
	(.3926)	(.3274)	(.3845)	(.4824)	(.451)	(.4839)

NOTES: ***p<0.01 **p<0.05 *p<0.1. Dependent variables are in the first column. Table only shows the coefficient on 1990 immigration from 2SLS specifications (instrument for contemporary immigration is a prediction of low-skilled immigration to the CZ using previous immigrant populations). All models also include a constant, indicators for sex and race/ethnicity, and 8th grade CZ characteristics: % adult population with a BA, % population without a high school diploma, and indicators for urbanicity (5 of them) and region (3 of them). Standard errors clustered at 8th grade CZ level.

Table 8: Immigration and Characteristics of Natives' Jobs in 2000

	(1)	(2)	(3)	(4)	(5)	(6)
	All respondents			Mother had high school or less		
		Control for Mother's Education (Years))	Control for Grade 8 % Limited English		Control for Mother's Education (Years)	Control for Grade 8 % Limited English
Communication tasks (general)						
Read letters, memos, or reports	.0256	.0208	.0298	.0342	.034	.0378
	(.0309)	(.0304)	(.0314)	(.0471)	(.0471)	(.0477)
Write letters, memos, or reports	.0236	.0179	.0217	.0481	.0474	.0434
	(.026)	(.0257)	(.0269)	(.0452)	(.0451)	(.0457)
Computer and communication tasks						
Use a computer	.0252	.0153	.0282	-.0072	-.0104	-.0057
	(.0312)	(.028)	(.0305)	(.0401)	(.0398)	(.039)
Use word processing	.0697*	.0623*	.0734**	.0446	.0438	.0577
	(.036)	(.0338)	(.0362)	(.0444)	(.0444)	(.0454)
Use e-mail	.063*	.0535*	.0693**	.0751	.0744	.0872*
	(.0329)	(.0309)	(.0335)	(.0479)	(.0477)	(.0477)
Use Internet	.0822**	.0684**	.0868**	.0996**	.0989**	.1135**
	(.035)	(.0324)	(.0356)	(.0462)	(.0456)	(.0456)
Manual tasks						
Measure size or weight of objects	-.0563**	-.0512*	-.0565**	-.0859*	-.0849*	-.0851*
	(.0274)	(.0264)	(.0278)	(.0439)	(.0437)	(.0438)

NOTES: ***p<0.01 **p<0.05 *p<0.1. Dependent variables are in the first column. Table only shows the coefficient on 1990 immigration from 2SLS specifications (instrument for contemporary immigration is a prediction of low-skilled immigration to the CZ using previous immigrant populations). All models also include a constant, indicators for sex and race/ethnicity, and 2000 CZ characteristics: % adult population with a BA, % population without a high school diploma, and indicators for urbanicity (5 of them) and region (3 of them). Standard errors clustered at 8th grade CZ level.

A Appendix: Derivation of Marginal Products

In this section, I derive the ratio of marginal products of foreign-born and native-born workers in the CES production function. To simplify notation, I suppress jkt subscripts. Let total output produced from immigrant (F) and native-born (D) labor inputs be Y. Then,

$$\ln Y = \frac{1}{\lambda} \ln[\psi(L^F)^\lambda + (1-\psi)(L^D)^\lambda]$$

So,

$$\frac{\partial \ln Y}{\partial L^F} = \frac{\lambda\psi(L^F)^{\lambda-1}}{\lambda[\psi(L^F)^\lambda + (1-\psi)(L^D)^\lambda]}$$

and since $\partial \ln Y/\partial L^F = Y^{-1}\partial Y/\partial L^F$, the marginal product of foreign-born workers is

$$\begin{aligned}\frac{\partial Y}{\partial L^F} &= [\psi(L^F)^\lambda + (1-\psi)(L^D)^\lambda]^{1/\lambda} \frac{\lambda\psi(L^F)^{\lambda-1}}{\lambda[\psi(L^F)^\lambda + (1-\psi)(L^D)^\lambda]} \\ &= [\psi(L^F)^\lambda + (1-\psi)(L^D)^\lambda]^{1/\lambda-1}\psi(L^F)^{\lambda-1}.\end{aligned}$$

Similarly, the marginal product of native-born workers' labor is

$$\begin{aligned}\frac{\partial Y}{\partial L^D} &= [\psi(L^F)^\lambda + (1-\psi)(L^D)^\lambda]^{1/\lambda} \frac{\lambda(1-\psi)(L^D)^{\lambda-1}}{\lambda[\psi(L^F)^\lambda + (1-\psi)(L^D)^\lambda]} \\ &= [\psi(L^F)^\lambda + (1-\psi)(L^D)^\lambda]^{1/\lambda-1}(1-\psi)(L^D)^{\lambda-1}.\end{aligned}$$

These imply that the ratio of marginal products of foreign-born and native labor is:

$$\frac{\partial Y/\partial L^F}{\partial Y/\partial L^D} = \frac{\psi(L^F)^{\lambda-1}}{(1-\psi)(L^D)^{\lambda-1}}$$

Equilibrium implies that wages equal marginal products of labor:

$$\frac{w^F}{w^D} = \frac{\psi(L^F)^{\lambda-1}}{(1-\psi)(L^D)^{\lambda-1}}$$

Taking logs yields Equation 1.

B Appendix: Supplemental Empirical Results

Table B.1: Regions of Origin for Categorizing Immigrants

1	Other North America
2	Central America
3	Caribbean
4	South America
5	Northern Europe
6	United Kingdom and Ireland
7	Western Europe
8	Southern Europe
9	Central/Eastern Europe
10	Baltic States
11	East Asia
12	Southeast Asia
13	India/Southwest Asia
14	Middle East/Asia Minor
15	Africa
16	Oceania (plus Antarctica and abroad unknown)

NOTES: Regions of immigrant origins in the U.S. Census. These are aggregations of country of birth given by the IPUMS variable BPL (birthplace). See Ruggles, et al. (2010) for more information.

Table B.2: Occupation Titles for NELS:88 Respondents, By Reported Job Task Frequency

	(1) % Read letters, memos a lot (Comm.)	(2) % Estimate Size and Weight a lot (Manual)	(3) Comm. ÷ Manual or (1) ÷ (2)
Legal professionals	86	0	.
Legal support	62	3	23
Human services professionals	54	4	13.29
Financial services professionals	66	6	10.68
Editors, writers, reporters	49	5	9.2
Business/financial support services	65	10	6.72
Secretaries and receptionists	64	11	5.9
Computer systems/related professionals	55	10	5.74
Protective services, criminal justice	72	15	4.86
Clerks, data entry	52	11	4.86
Educators-instructors other than K-12	37	10	3.89
Educators-K-12 teachers	64	17	3.83
Computer programmers	37	10	3.57
Customer service	58	17	3.5
Military	68	21	3.22
Sales/purchasing	58	25	2.34
Clerical other	48	23	2.06
Managers-supervisory, office, other Admi	59	30	1.97
Managers-executive	67	38	1.76
Managers-midlevel	61	36	1.69
Health/recreation services	39	24	1.64
Technical/professional workers, other	57	39	1.47
Engineers architects software engineers	56	44	1.27
Computer/computer equipment operators	48	39	1.22
Medical licensed professionals	41	35	1.17
Medical services	43	38	1.14
Cashiers, tellers, sales clerks	29	26	1.13
Performers/artists	28	27	1.07
Mechanic, repairer, service technicians	36	45	.81
Personal services	18	22	.8
Scientist, statistician professionals	57	71	.8
Medical practice professionals	50	67	.75
Research assistants/lab technicians	33	52	.63
Farmers, foresters, farm laborers	30	50	.61
Transport operatives (not pilots)	36	60	.6
Laborers (other than farm)	25	48	.53
Cooks, chefs, bakers, cake decorators	26	55	.47
Skilled operatives	26	61	.43
Craftsmen	23	72	.32

NOTES: Data from the NELS:88 final (2000) follow-up survey. It asked respondents currently working for pay how often they "read letters, memos, or reports" in a typical week at work. Column 1 shows the percent of respondents answering "a lot" (rather than "never" or "occasionally") in each occupation. Working respondents were asked how often they "measure or estimate the size or weight of objects" on the job. Column 2 shows the percent of respondents answering "a lot" in each occupation. Column 3 divides column 1 by column 2 to identify occupations where communication tasks are employed much more frequently than manual tasks.