The Effect of Immigration on Output Mix, Capital, and Productivity

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The fraction of the U.S. population composed of the foreign-born reached 11 percent in 2000, the highest in seventy years. The large number of immigrants in the United States has prompted concern about possible negative effects on labor market outcomes among natives. Such concerns are particularly widespread among less-skilled workers because the proportion of immigrants who have not completed high school is at least twice that of natives (U.S. Census Bureau 2000).

These concerns have not been borne out by much of a large literature examining immigration's effects on wages. A number of studies have found little correlation between immigration inflows and changes in wages at the metropolitan or state level.[1] Changes in industry composition, labor productivity, capital, or other factors may explain why immigration does not appear to affect wages at the regional level. For example, the output mix in an area may change in response to immigration flows, with areas experiencing an influx of low-skilled immigrants becoming more specialized in production of low-skilled outputs. If immigrants are a complement to some groups of native workers, such as low-skilled immigrants complementing high-skilled natives, an increase in labor productivity may occur for some workers; wage increases for workers with increased productivity could offset lower wages for other workers, leading to no change in average wages. Movement of capital or workers across sectors or areas could also account for the lack of measured changes in wages observed in many studies.

Several previous studies suggest that immigration flows may affect output mix, productivity, and capital in the United States. Hanson and Slaughter (1999) report that industry composition in California, which has experienced a large, sustained inflow of immigrants, shifted toward labor-intensive industries relative to other large states during the 1980s. Altonji and Card (1991) find that low-wage service and manufacturing industries and agriculture account for a larger share of total employment in high-immigration cities in the United States than in low-immigration cities.[2] McCarthy and Vernez (1997) find that capital investment and value added in manufacturing grew more slowly in California than in the rest of the United States during the 1963–92 period; they attribute this finding in part to the large immigrant flows to that state. In contrast, a simulation of immigration's effect on capital and other factors at the national level suggests that increased immigrant inflows boost capital levels (Chiswick, Chiswick, and Karras 1992).

This study examines the relationship between immigration and output mix, labor productivity, and capital in the manufacturing sector. The analysis makes several contributions to the literature, which has devoted relatively little attention to the effect of immigration on factors other than wages. Although

a few studies have examined immigration and output mix, productivity, or capital, previous research has not examined the impact of immigration on all three factors. The relationship between immigration and capital investment has received particularly little attention because data on capital are available for few industries. Understanding the effect of immigration on capital, output mix, and productivity is important when assessing the overall effect of immigration as well as in reconciling the typical empirical result—that immigration does not significantly lower wages—with the theoretical negative effect predicted by most models.

Changes in industry composition, labor productivity, capital, or other factors may explain why immigration does not appear to affect wages at the regional level.

The article develops a simple two-sector model to predict the expected relationship between immigration inflows to a state and output mix, capital usage, and productivity. These predictions are then tested using data from the 1982 and 1992 Census of Manufactures and other sources. The results indicate that immigration inflows do not affect changes in output mix between low- and high-skilled manufacturing industries across states. However, it appears that the fraction of employment in low-skilled manufacturing industries has increased and productivity has risen more slowly in states that received more immigrants relative to other states.

Theoretical Model

To illustrate the expected effects of immigration flows on sectoral composition, capital, and productivity at the state level, this analysis develops a simple two-sector model. Each state, which is treated as a small open economy, has two sectors. Both sectors use capital in production, and one sector uses skilled labor while the other uses unskilled labor. Each sector's production function is represented by

$$Y^i = f^i(L^i, K^i), \tag{1}$$

where Y is output, L is labor, K is capital, and i is equal to either s (skilled) or u (unskilled).

The model assumes that labor in each sector is composed of two types of workers, natives and immigrants, who are perfectly substitutable within sectors. In other words, skilled immigrants are perfect substitutes for skilled natives in the skilled sector, and neither skilled immigrants nor skilled natives work in the unskilled sector. The number of immigrants in each skill group and state is exogenous with respect to wages and other factors in the model. The number of natives in each skill group and state is fixed; this assumption is discussed further below. The total number of workers in sector i is given by

$$L^i = N^i + I^i, \tag{2}$$

where N represents natives and I represents immigrants. Because they are perfect substitutes within skill groups, natives and immigrants earn the same wage, w^i, in sector i. Under the assumption that native labor is fixed within states and sectors, changes in the number of immigrants within a sector are equivalent to changes in total labor in that sector.

Within each state, capital is assumed to be perfectly mobile across sectors and the total amount of capital is assumed to be fixed, so an increase in capital in one sector implies an equal reduction in capital in the other sector.[3] The return to capital is therefore equalized across sectors within each state and is given by r_s, which is equal to the value of the marginal product of capital in state s. If both industries are perfectly competitive across states, the prices of the two output goods, denoted p^i, are equal across states.

Totally differentiating equation (1) and assuming that native labor is fixed yields the determinants of changes in capital in sector i:

$$dK^i = \left(\frac{f^i_{KL} f^j_K}{z}\right) dI^i - \left(\frac{f^j_{KL} f^i_K}{z}\right) dI^j + \left(\frac{f^i_K f^j_K}{z}\right)\left[\frac{dp^i}{p^i} - \frac{dp^j}{p^j}\right] \tag{3}$$

where $i \neq j$ and $z = -(f^i_{KK} f^j_K + f^j_{KK} f^i_K)$, which is positive. Assuming that the marginal products of labor and capital are positive in both sectors and that labor and capital are complements within each sector, the first term in equation (3) implies that an increase in immigrant workers in a given sector will raise the amount of capital in that sector. The second term implies that an increase in immigrant workers in the other sector will lower the amount of

capital used in a given sector as capital moves to the other sector. If the number of immigrant workers increases in both sectors in a given state, capital will increase in the sector with a larger increase in immigrants and will decline in the other sector. The last term in equation (3) indicates that a sector uses more capital as the price of its output increases relative to the output price for the other sector. Changes in capital allocation across sectors within a state will therefore depend on relative changes in the number of skilled and unskilled immigrants in that state, with a larger inflow of skilled immigrants relative to unskilled immigrants raising the fraction of capital utilized in the skilled sector, and on changes in relative prices.

Changes in output in each state and sector can be determined by taking the total derivative of the production function for a given sector. Assuming that native labor is fixed, taking the total derivative of equation (1) and substituting in equation (3) gives the determinants of changes in output in sector i:

$$(4)\quad dY^i = \frac{(f_K^i)^2 f_K^j}{z}\left[\frac{dp^i}{p^i} - \frac{dp^j}{p^j}\right] + \left[f_L^i + \frac{f_{KL}^i f_K^j f_K^i}{z}\right]dI^i - \left[\frac{(f_K^i)^2 f_{KL}^j}{z}\right]dI^j.$$

The first term in equation (4) implies that output in sector i increases as the price of the output good increases relative to the output price in the other sector. The second term indicates that output in a given sector increases as immigration of workers with the skills utilized in that sector increases—in other words, the skilled sector produces more if a state receives a larger number of skilled immigrants. Higher immigration levels of workers with skills used in the other sector lowers output in a sector, however, as indicated by the last term in equation (4). This negative effect occurs because capital is a complement to labor and is fixed in a given state; if the other sector receives an influx of workers and needs more capital, output in a given sector will fall if other factors are held constant.

The same factors that determine changes in output in each sector also determine changes in the output mix. Changes in the fraction of total output in a given sector depend on relative changes in skilled and unskilled labor and on relative prices. The fraction of output produced in the unskilled sector will increase as unskilled immigrant inflows increase relative to skilled immigrant inflows and as the price of the unskilled output rises relative to the price of the skilled output good.

The model can also be used to determine which factors affect labor productivity, or output per worker. Changes in labor productivity are given by

$$(5)\quad d\left(\frac{Y^i}{L^i}\right) = \frac{1}{L^i}\left[\frac{(f_K^i)^2 f_K^j}{z}\left(\frac{dp^i}{p^i} - \frac{dp^j}{p^j}\right) + \left(f_L^i + \frac{f_{KL}^i f_K^j f_K^i}{z} - \frac{Y^i}{L^i}\right)dI^i - \left(\frac{(f_K^i)^2 f_{KL}^j}{z}\right)dI^j\right],$$

where the first term indicates that an increase in the relative output price acts to raise productivity. The second term shows the effect that immigration inflows in a sector have on productivity in that sector. The predicted sign of the effect is ambiguous and depends on the relationship between output, labor, and capital. The third term gives the effect of immigration inflows to sector j; increases in these inflows unambiguously reduce labor productivity in sector i. Changes in labor productivity in each sector are therefore affected by changes in relative prices and by immigration inflows to each sector.

The assumptions underlying the model imply that relative factor prices are equalized across states because each state is a small open economy. Immigration can affect the level of wages for unskilled and skilled workers and the return to capital in a state, but it does not affect relative wages or the relative return to capital (relative to other production factors) within or across states. This analysis therefore does not focus on immigration's effect on wages and the return to capital in the empirical section below; as discussed above, most previous research has found at most small effects of immigration on wages at the local level. Because the model assumes that each state is small enough that its output does not affect

1. See, for example, Card (2001) and the papers surveyed in Borjas (1994) and Friedberg and Hunt (1995). However, general equilibrium studies (Borjas, Freeman, and Katz 1997; Jaeger 1996; Johnson 1998) tend to report larger adverse wage effects than do cross-area studies.
2. However, Gandal, Hanson, and Slaughter (2000) conclude that there is little evidence that output mix in Israel changed in response to the influx of skilled Russian immigrants during the 1990s.
3. Relaxing this assumption to allow capital mobility across states does not change the predicted relationships in the model.

prices, immigration does not affect output prices in the model.[4]

This simple model has several limitations. First, treating the number of natives within skill groups and states as fixed is clearly a simplification since natives can migrate to other states or change skill groups, particularly in the long run. Such changes are likely to be endogenous with respect to wages and immigration flows. For example, an influx of unskilled immigrants to a state might lower wages for unskilled workers in that state, prompting unskilled natives to move to other states. However, Card (2001), Card and DiNardo (2000), and Kritz and Gurak (2001) find that natives' and other immigrants' locational choices and migration patterns are generally unresponsive to immigrant inflows.[5] This simplification allows the analysis to focus on the effect of changes in labor supply due to immigration on output mix, capital, and productivity instead of on native labor flows. Another way to view the model and empirical methodology is as a reduced form in which immigrant inflows implicitly serve as an instrumental variable for changes in the supply of workers in an industry; this interpretation is discussed further in the empirical methodology section below.

The model's predictions are tested using data on changes in the fraction of output, employment, and capital investment in low-skilled manufacturing industries and on changes in immigration.

Another simplification made by the model is that the total amount of capital does not change within states: only its allocation across sectors changes. This assumption simplifies the model algebraically, but all the predictions are similar if capital is mobile across states as well as across sectors. The analysis below examines how the fraction of capital investment in the unskilled sector relative to the skilled sector changes in response to the skill level of new immigrants.

Unlike many previous studies (for example, Grossman 1982; Borjas 1983), this analysis does not use the model to examine whether immigrants are substitutes or complements for natives in the same or other skill group. Previous research tends to conclude that immigrants are substitutes for other immigrants but has differed on the substitutability of immigrants for natives. Estimating such cross-elasticities requires making strong assumptions about the form of the production function. This article instead focuses on the effect of immigrant inflows on output mix, asking whether having a greater inflow of unskilled immigrants increases production in the unskilled sector relative to the skilled sector. The effect of immigrant inflows on capital usage and labor productivity in the unskilled and skilled sectors within the manufacturing sector is also examined.

Empirical Methodology

In cross-state comparisons, the model predicts that states with larger inflows of unskilled immigrants relative to skilled immigrants should experience an increase in the fraction of output produced in the unskilled sector compared with other states. Similarly, states with relatively larger inflows of unskilled immigrants should have relatively larger increases in capital investment in the unskilled sector as a fraction of total capital investment. The predicted effect of immigration inflows on labor productivity is ambiguous. The model's predictions are tested using data on changes in the fraction of output, employment, and capital investment in low-skilled manufacturing industries and on changes in immigration for the fifty states and the District of Columbia. The relationship between changes in labor productivity in both the high-skilled and low-skilled sectors and changes in immigration is also examined.

To examine the relationship between immigration and output mix, the change between 1982 and 1992 in value added in the low-skilled sector as a fraction of total value added in manufacturing is regressed on a measure of immigration and other controls. Immigration inflows are measured as the change in the percentage of each state's population aged sixteen and older that is foreign born. This measure of immigration inflows ignores skill differences among immigrants; the robustness of the results using other measures of immigration inflows is discussed below.

The regressions also control for other measures of economic conditions that are likely to be associated with changes in output mix, capital investment, and labor productivity, such as the educational distribution of the population, tax structure, state government expenditures, urbanization, and unionization. All covariates except the change in the foreign-born population share are measured at the beginning of the ten-year period because changes in economic and demographic conditions may be endogenous with respect to production inputs and outputs. These variables are detailed in the data section below.

Although this model predicts that changes in relative prices affect changes in output, a measure of relative prices is not included in the regressions because data on changes in relative prices across states are not available. If goods markets are perfectly competitive, changes in relative prices should be the same across states, and the constant in the regressions will capture this effect. Another potential concern is that the measure of output used here, value added, confounds changes in price and quantity. The change in the fraction of employment in the low-skilled sector is therefore also examined because it offers a means of estimating the relationship between immigrant inflows and output mix that does not directly include output price effects.

The empirical model for capital is similar to the models for output mix and employment. The change between 1982 and 1992 in capital investment in the low-skilled sector as a fraction of total capital investment in manufacturing is regressed on the change in the fraction of the population that is foreign born and the other controls. To examine the relationship between labor productivity and immigration, separate models are estimated for the percentage change between 1982 and 1992 in labor productivity in the low-skilled and high-skilled manufacturing sectors. The covariates again include the change in the fraction of the population born abroad and the other control variables.

This empirical strategy of examining changes over a ten-year period in production inputs and outputs implicitly controls for time-invariant differences across states. All regressions include a constant, which captures the average change over time. The basic specifications are estimated using ordinary least squares, with observations weighted by total employment in manufacturing in a state in 1982. The standard errors are White-corrected for heteroscedasticity.

This approach of regressing changes in output mix, employment, capital, or labor productivity on changes in the foreign-born population share requires assuming that changes in the immigrant population share are exogenous. If changes in the fraction of the population that is foreign born instead depend on shocks to output, productivity, or other inputs, the results would be biased. The analysis examines the robustness of the basic results to instrumenting for the change in the foreign-born population share with the initial share in 1980 since new immigrants tend to settle where previous immigrants live (Bartel 1989; Zavodny 1999). As noted above, the basic regression approach can be viewed as a reduced form in which immigrant inflows implicitly serve as an instrumental variable for the change in the labor supply. Immigrant inflows are less likely to be affected by shocks to output mix, productivity, and inputs than native flows since most new immigrants settle where previous immigrants live, making the change in the foreign-born population share a reasonably exogenous measure of changes in labor supply. Instrumenting for the foreign-born population share should even further reduce any potential endogeneity bias.

This article's approach differs from previous research in several ways. First, the analysis focuses only on the manufacturing sector since data on capital as well as value added and employment are available for manufacturing industries. Employment shares in the manufacturing sector are discussed in the data section. Unlike Hanson and Slaughter (1999), who focus on the twelve states that receive the largest immigrant inflows, this analysis examines all states because those that receive smaller numbers of immigrants should experience smaller changes in output mix and other factors than states that are the primary destinations for immigrants.

Data

The main data sources for this analysis are the decennial Census of Population and Housing and the Census of Manufactures, an establishment-level survey conducted every five years. From the population survey data, this analysis calculates the percentage of the population aged sixteen and older that is foreign born in 1980 and 1990, the percentage aged twenty-five and older that graduated from high school (but not college), the percentage that graduated from college, and the percentage living in metropolitan areas in 1980. These population measures are supplemented with data on the fraction of workers who are union members in 1980, the fraction of state tax revenues from individual income taxes and from corporate net income taxes in 1982,

4. The measure of output used in the empirical analysis below is the value of output, so changes in quantities produced cannot be disentangled from changes in prices. The analysis does control for changes in relative prices to the extent that changes in relative prices of skilled and unskilled manufactured goods are the same across states.
5. A few studies have concluded that immigration inflows do affect natives' location choice (for example, Filer 1992; Borjas, Freeman, and Katz 1997). The comments and discussion section of Borjas, Freeman, and Katz provides several potential explanations for the different results.

TABLE 1

Education Shares within U.S. Manufacturing Sectors, 1980 and 1990

Sector	Two-digit SIC code	High school or less 1980	High school or less 1990	College grad. 1980	College grad. 1990
High-skilled:					
Petroleum refining	29	.537	.413	.219	.264
Chemicals	28	.575	.438	.221	.285
Printing	27	.576	.449	.186	.242
Instruments	38	.580	.435	.186	.250
Electrical machinery	36	.641	.479	.148	.225
Transportation equipment	37	.642	.486	.139	.207
Machinery	35	.650	.504	.131	.189
Low-skilled:					
Miscellaneous	39	.729	.613	.105	.138
Tobacco	21	.735	.541	.104	.179
Fabricated metals	34	.738	.636	.087	.104
Paper	26	.739	.635	.103	.124
Rubber	30	.743	.650	.092	.108
Stone/clay/glass	32	.747	.651	.091	.113
Food products	20	.755	.661	.089	.116
Primary metals	33	.758	.564	.084	.101
Lumber	24	.804	.737	.059	.067
Furniture	25	.810	.720	.060	.073
Textiles	22	.844	.770	.056	.069
Apparel	23	.867	.779	.043	.069
Leather	31	.871	.783	.037	.070
All manufacturing		.700	.571	.119	.166

Note: Education shares are calculated from the 1980 and 1990 Census of Population and Housing, 5 percent sample.

and state and local education and highway expenditures per capita in 1982.[6]

The production measures are created from the Census of Manufactures in 1982 and 1992. The Census of Manufactures includes data on the number of workers, value added, new capital expenditures, and payroll at the four-digit standard industrial classification (SIC)–code level. Total value added (output), employment, new capital investment, and value added per employee for twenty industries within the manufacturing sector at the two-digit SIC-code level were constructed. Industries were classified as high- or low-skilled on the basis of the educational attainment of workers in those industries and aggregated to two sectors, high-skilled and low-skilled, for each state (Table 1 lists the detailed industries in each sector).[7] Because of confidentiality requirements associated with small sample sizes, data for some two-digit industries are not available for all states. Because these industries compose a small proportion of manufacturing within those states, most of the analysis does not account for the fact that not all industries are included in each state when constructing the measures for the high- and low-skilled sectors; the robustness of the results using a subsample of states with data available for a consistent set of industries in 1982 and 1992 is checked below.

This analysis examines only the manufacturing sector because data on capital investment are available for that sector. In the 1980 and 1990 Census of Population, almost 19 percent of native workers aged sixteen and older were employed in the manufacturing sector compared with over 21 percent of foreign-born workers. About 9 percent of native workers and 12 percent of foreign-born workers were employed in the manufacturing industries classified here as low-skilled. The manufacturing sector therefore encompasses a substantial proportion of workers, including a disproportionate number of foreign-born workers.

The analysis is conducted at the state level, creating a sample size of fifty-one observations. State-level data are used instead of data at the metropolitan statistical area (MSA) level because the boundaries of some MSAs changed between the 1982 and 1992 economic censuses.

Table 2 reports the sample means for the variables. Value added in the low-skilled manufacturing sector declined as a fraction of total value added in manufacturing between 1982 and 1992, on average, as did the fraction of new capital investment in the low-skilled sector. In contrast, the fraction of employment in the low-skilled sector increased slightly. Value added per worker rose in both sectors (in nominal terms), with the increase about 6 percentage points larger in the high-skilled sector than in the low-skilled sector. The foreign-born population share rose by almost 3 percentage points, reflecting the high immigration levels between 1980 and 1990.

TABLE 2

Descriptive Statistics

	Mean
Percentage change, 1982–92, in:	
Fraction of output	–1.35
in low-skilled sector	(4.27)
Fraction of capital investment	–.74
in low-skilled sector	(7.40)
Fraction of employment	.21
in low-skilled sector	(.36)
Labor productivity	54.97
in low-skilled sector	(8.17)
Labor productivity	61.29
in high-skilled sector	(9.90)
Change in percentage of population	2.83
foreign born, 1980–90	(3.08)
Population graduated from	50.21
high school (%), 1980	(4.70)
Population graduated from	16.17
college (%), 1980	(2.79)
Tax revenue from individual	28.41
income taxes (%), 1982	(15.24)
Tax revenue from corporate	8.58
net income taxes (%), 1982	(4.04)
Education expenditures	.06
per capita, 1982	(.09)
Highway expenditures	.01
per capita, 1982	(.02)
Metropolitan (%), 1980	77.25
	(16.70)
Union (%), 1980	25.20
	(8.82)
Number of observations	51

Notes: Standard deviations are in parentheses. Observations are weighted by total employment in manufacturing in each state in 1982.

Results

Immigration appears to have little effect on output mix. As column 1 of Table 3 reports, changes in the foreign-born population share are not associated with changes in the share of value added in the low-skilled manufacturing sector. As the sample means suggest, the negative coefficient on the constant indicates that the share of output produced in the low-skilled sector declined on average. Between 1982 and 1992, states with a higher fraction of workers that graduated from high school but not college experienced a smaller decline in the share of value added in the low-skilled sector, but this share declined relatively more in states that raised a larger percentage of tax revenue through individual income taxes and that were more urban.

Immigration also appears to have little effect on relative changes in capital investment across sectors (column 2). The share of investment in the low-skilled sector declined more in states with higher shares of tax revenue from individual income taxes.

Immigration does appear to be related to changes in both employment shares and labor productivity. The fraction of employment in the low-skilled sector increased more in states with larger increases in the foreign-born population share. The increase in the employment share in the low-skilled manufacturing sector is also positively associated with the fraction of the population that graduated from high school but not college and with the unionization rate. Changes in employment shares across sectors also appear related to state tax structure and urbanization. States with larger increases in the foreign-born population share experienced smaller increases in productivity in both the low- and high-skilled sectors (Table 3, columns 4 and 5). Consistent with the positive relationship of immigration with low-skilled employment shares and zero relationship with low-skilled output shares, the negative coefficient on the immigration variable is larger in absolute value for changes in productivity in the low-skilled sector than in the high-skilled sector. Labor productivity in the high-skilled sector increased more in states that were more metropolitan and less in states with a

6. The union, tax, and expenditure data are from the Census Bureau's *Statistical Abstract*. Data for 1982 on the population, metropolitan, and union variables were not available.
7. Industries were classified based on the national fraction of workers in that industry who had a high school education or less in 1980 according to the 1980 Census of Population and Housing. Using the fraction of workers who had graduated from college or data from the 1990 Census would yield the same classification of industries, as Table 1 indicates.

TABLE 3

Ordinary Least Squares Regression Results

	Output	Capital	Employment	Low-skilled productivity	High-skilled productivity
Foreign-born population share	.221	–.131	.316*	–1.639**	–1.322**
	(.181)	(.352)	(.157)	(.415)	(.394)
High school graduates	.322**	.052	.272**	–.005	–.008*
	(.105)	(.229)	(.082)	(.003)	(.003)
College graduates	.565	.869	.379	–.001	–.006
	(.364)	(.549)	(.316)	(.007)	(.007)
Individual income tax revenue	–.118*	–.176*	–.126**	.061	.012
	(.046)	(.068)	(.041)	(.108)	(.101)
Corporate income tax revenue	.001	.049	.027	.216	.265
	(.131)	(.271)	(.135)	(.306)	(.309)
Education expenditures	.287	.420	.124	.679	–.083
	(.213)	(.486)	(.185)	(.516)	(.454)
Highway expenditures	–1.833	–3.298	–1.240	–3.331	–.226
	(1.118)	(2.354)	(.921)	(2.251)	(2.300)
Metropolitan	–.206**	–.202	–.149**	.129	.399*
	(.060)	(.107)	(.043)	(.117)	(.159)
Union	.245**	.198	.224**	–.179	–.217
	(.090)	(.153)	(.072)	(.235)	(.271)
Constant	–.135*	–.001	–.105**	.785**	.866**
	(.055)	(.093)	(.039)	(.182)	(.203)
Adjusted R^2	.398	.145	.479	.326	.401

Notes: The asterisk (*) indicates $p \leq .05$; the double asterisk (**) indicates $p \leq .01$. Standard errors are in parentheses. Observations are weighted by total employment in manufacturing in each state in 1982. The number of observations is fifty-one.

larger fraction of the population that finished high school but not college.

All the results are robust to several other measures of immigration inflows. In results not shown here, the results are similar to those in Table 3 if the share of new (post-1979) immigrants relative to the state population, the share of new immigrants who settle in a given state, or the change in the share of the foreign-born present in the United States and living in a given state is included in the regressions instead of the change in the share of foreign-born relative to the state population. In particular, immigration is positively associated with the change in the share of employment in the low-skilled sector and negatively associated with the change in labor productivity in each sector, with the estimated relationship larger in the low-skilled sector than in the high-skilled sector.

Because the model distinguishes between skilled and unskilled immigrants, this study also investigates the robustness of the results to splitting the foreign-born population share variable into education groups. About 41 percent of the foreign-born aged twenty-five and older did not complete high school, and about 39 percent attended at least some college. Variables measuring the change in the number of foreign-born who did not complete high school relative to the state population aged twenty-five and older and the change in the number who did complete high school relative to the population were constructed to serve as proxies for the change in the supply of unskilled and skilled labor, respectively. The average change in the low-education foreign-born population share between 1980 and 1990 was about 0.4 percent, compared with a 1.9 percent average increase in the high-education foreign-born population share.[8]

Table 4 shows the results of including separate variables measuring changes in the unskilled and skilled labor supply due to immigration inflows. The results are generally similar to those reported in Table 3 and indicate that changes in the low-education foreign-born population underlie the observed relationships between immigration and changes in employment shares and labor productivity. States that experienced a larger increase in the low-education foreign-born population share had a larger increase in the fraction of employment in low-skilled manufacturing industries (column 3). The change in the high-education foreign-born population share is negatively associated with the change in the fraction of employment in the low-skilled sector, as the model predicts, but the relationship is not significant. The change in the low-education foreign-born population share is negatively associated with changes in labor productivity in the low-

TABLE 4

Ordinary Least Squares Regression Results, with Immigration Inflows by Skill Level

	Output	Capital	Employment	Low-skilled productivity	High-skilled productivity
Low-education foreign-born population share	1.208	1.617	1.386*	–3.502**	–2.593
	(.601)	(1.274)	(.605)	(1.083)	(1.734)
High-education foreign-born population share	–.879	–2.092	–.852	.248	.003
	(.762)	(1.825)	(.765)	(1.309)	(2.296)
High school graduates	.237	–.108	.183	–.396	–.685
	(.132)	(.309)	(.094)	(.341)	(.371)
College graduates	.750	1.173	.577	–.448	–.889
	(.377)	(.718)	(.298)	(.778)	(.936)
Individual income tax revenue	–.108*	–.159*	–.116**	.047	.002
	(.048)	(.077)	(.042)	(.105)	(.101)
Corporate income tax revenue	.036	.103	.067	.125	.201
	(.130)	(.252)	(.133)	(.301)	(.283)
Education expenditures	.259	.352	.096	.696	–.083
	(.190)	(.457)	(.170)	(.550)	(.423)
Highway expenditures	–1.672	–2.922	–1.072	–3.469	–.273
	(.976)	(2.253)	(.806)	(2.446)	(2.188)
Metropolitan	–.178*	–.154	–.119*	.078	.361*
	(.072)	(.115)	(.051)	(.123)	(.165)
Union	.274**	.248	.256**	–.240	–.258
	(.097)	(.198)	(.072)	(.242)	(.306)
Constant	–.140*	–.001	–.110**	.810**	.887**
	(.056)	(.097)	(.038)	(.180)	(.203)
Adjusted R^2	.418	.166	.513	.344	.404

Notes: The asterisk (*) indicates $p \leq .05$; the double asterisk (**) indicates $p \leq .01$. The low-education foreign-born population share variable is the change in the number of foreign-born who did not complete high school relative to the state population aged twenty-five and older. The high-education foreign-born population share is the change in the number of foreign-born who completed at least high school relative to the state population aged twenty-five and older. Standard errors are in parentheses. Observations are weighted by total employment in manufacturing in each state in 1982. The number of observations is fifty-one.

skilled sector, and neither measure of immigration flows is significantly associated with changes in labor productivity in the high-skilled sector.

In most of the regressions shown in Table 4, the variable measuring the fraction of the population that completed high school but not college loses significance in comparison with the results in Table 3. This difference occurs because the education distribution variable is collinear with the variables measuring the change in foreign-born population shares by educational attainment, indicating that the educational distribution of immigrants is related to the distribution in areas where they settle.

Because Census of Manufactures data are not available for all manufacturing sectors at the two-digit level in some states, changes in production outputs and inputs may reflect changes in the detailed industries included in the data. The variables were therefore also constructed using Census of Manufactures data only for those two-digit industries observed in both 1982 and 1992; the primary industry not included when constructing the balanced data was the tobacco industry. The results are similar to those reported in Table 3 and are not shown here.

If immigrants choose to settle in states in which the demand for workers with their skill levels is rising, the change in the foreign-born population share would be endogenous in the regressions. Instrumental variables techniques were therefore used, with the change in the foreign-born population share between 1980 and 1990 instrumented with the foreign-born population share in 1980. In the first-stage regressions, which are

8. The total change (2.3 percent) is slightly less than the change in the foreign-born population share given in Table 2 because these changes are measured among the population aged twenty-five and older, whereas the change in the foreign-born population share reported in Table 2 and used in Tables 3 and 5 is measured among the population aged sixteen and older. The education measures include only people aged twenty-five and older to allow for the time during which people typically complete their education. The average age of the foreign-born population is younger than the average age of the native population.

TABLE 5

Instrumental Variables Regression Results

	Output	Capital	Employment	Low-skilled productivity	High-skilled productivity
Foreign-born population share	.258	–.342	.239	–1.379*	–1.541**
	(.269)	(.543)	(.221)	(.576)	(.547)
High school graduates	.324**	.042	.268**	–.006	–.008*
	(.106)	(.238)	(.083)	(.003)	(.003)
College graduates	.550	.953	.409	–.002	–.004
	(.363)	(.608)	(.311)	(.008)	(.007)
Individual income tax revenue	–.119*	–.173*	–.124**	.056	.016
	(.046)	(.070)	(.042)	(.110)	(.101)
Corporate income tax revenue	.004	.031	.020	.238	.247
	(.134)	(.278)	(.138)	(.314)	(.311)
Education expenditures	.279	.468	.142	.620	–.034
	(.218)	(.495)	(.199)	(.491)	(.465)
Highway expenditures	–1.797	–3.505	–1.315	–3.077	–.440
	(1.139)	(2.403)	(.987)	(2.142)	(2.336)
Metropolitan	–.209**	–.184	–.142**	.107	.417**
	(.066)	(.106)	(.049)	(.122)	(.155)
Union	.247**	.188	.220**	–.167	–.227
	(.091)	(.151)	(.072)	(.236)	(.267)
Constant	–.133*	–.015	–.109**	.801**	.852**
	(.056)	(.092)	(.040)	(.183)	(.203)
Adjusted R^2	.397	.142	.477	.322	.399

Notes: The asterisk (*) indicates $p \leq .05$; the double asterisk (**) indicates $p \leq .01$. The change in the foreign-born population share is instrumented with the foreign-born population share in 1980. Standard errors are in parentheses. Observations are weighted by total employment in manufacturing in each state in 1982. The number of observations is fifty-one.

not shown here, the change in the foreign-born population share is strongly correlated with the initial foreign-born population share, with the t-statistic on the foreign-born share variable around 10. Table 5 shows the second-stage results.

The positive relationship between immigration and changes in employment shares weakens when instrumenting for the change in the foreign-born population share (column 3). This weakening suggests that immigrants may choose where to live based in part on changes in the demand for labor, and immigration flows may not affect employment shares after endogeneity is controlled for. The negative relationship between immigration and labor productivity remains significant, indicating that labor productivity increases more slowly in states with larger increases in their foreign-born population share.

Conclusion

This article develops a two-sector model of changes in output mix, capital, and labor productivity in which unskilled and skilled labor and capital are the inputs in the production process. The model's predictions for changes in the labor supply are tested using data on immigration and low- and high-skilled manufacturing industries. The results indicate that changes in the labor supply due to immigration appear to lower labor productivity in both the low- and high-skilled sectors. This finding does not indicate that immigration lowers labor productivity but rather that labor productivity increased more slowly in states that attracted a larger share of immigrants during the 1980s. This slower productivity growth may be the result of the gradual process of assimilation for many immigrants; the negative effect on productivity growth may disappear as immigrants acquire language skills and familiarity with U.S. labor market institutions. The longer-run effect of immigration on productivity is a topic for further research.

Some of the results suggest that immigration inflows increase the share of employment in the low-skilled sector, as previous studies have also found, but the results are not robust to controlling for endogeneity. Combined with the failure to find effects on output mix in this analysis, these results suggest that changes in the allocation of production across industries, at least within the manufacturing sector, are unlikely to underlie other studies' failure to find significant adverse wage effects at the regional level.

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