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Task Specialization, Immigration, and Wages

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Non-Technical Abstract

Many workers with low levels of educational attainment immigrated to the United States in recent decades. Large inflows of less-educated immigrants would reduce wages paid to comparably-educated native-born workers if the two groups are perfectly substitutable in production. In a simple model exploiting comparative advantage, however, we show that if less-educated foreign and native-born workers specialize in performing different tasks, immigration will cause natives to reallocate their task supply, thereby reducing downward wage pressure. We merge occupational task-intensity data from the O*NET and DOT datasets with individual Census data across US states from 1960-2000 to demonstrate that foreign-born workers specialize in occupations that require manual and physical labor skills while natives pursue jobs more intensive in communication and language tasks. Immigration induces natives to specialize accordingly. Simulations show that this increased specialization might explain why economic analyses commonly find only modest wage and employment consequences of immigration for less-educated native-born workers across U.S. states. This is especially true in states with large immigration flows.

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JEL Codes: F22, J61, J31, R13.

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Abstract

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1 Introduction

Immigration has significantly affected the US labor market during the last few decades, particularly increasing the supply of workers with low levels of formal schooling. Economists continue to debate the wage effects of these large inflows on native-born workers. If workers' skills are differentiated solely by their level of educational attainment, and if the production technology and productivity of each type of labor are given, then a large flow of immigrants with limited schooling should change the relative scarcity of education groups, increase wages paid to highly-educated natives, and reduce wages paid to less-educated ones. Borjas (2003, 2006) and Borjas and Katz (2005) adopt this intuitive approach and use US national-level data to argue that immigration reduced real wages paid to native-born workers without a high school degree by four to five percent between 1980 and 2000. Area studies by Card (2001, 2007), Card and Lewis (2007), and Lewis (2005), in contrast, employ city and state level data and find almost no effect of immigration on the wages of less-educated native workers. Moreover, they fail to find evidence that natives respond to immigration by moving to areas with fewer foreign-born workers. Ottaviano and Peri (2006) note that the effect of immigration on native wages crucially depends upon the degree of substitution between native and foreign-born workers *within* each education group. That is, native and foreign-born workers of comparable educational attainment might possess unique skills that lead them to specialize in different occupations, which would mitigate natives' wage losses from immigration.[1] Lewis (2005) argues that if technological adoption adjusts to the availability of different types of labor, regions with larger populations of less-educated immigrants might use less-educated labor more productively, which helps avoid negative wage implications.

We advance this debate by developing a theory and performing empirical analysis to demonstrate *how* native and foreign-born workers with little formal education are imperfect substitutes in production. We argue that less-educated workers specialize in differentiated production tasks. Immigrants are likely to have imperfect language (or equivalently, "communication") skills, but they possess physical (or "manual") skills similar to those of native-born workers. Thus, they have a comparative advantage in occupations requiring manual labor tasks, while less-educated native-born workers will have an advantage in jobs demanding communication skills. Immigration encourages workers to specialize accordingly. Importantly, language-intensive tasks earn a comparatively higher return and those returns are further enhanced by the increased supply of manual-intensive tasks that complement them. Therefore, productivity gains from specialization coupled with the high compensation paid to communication skills together imply that foreign-born workers do not create large adverse consequences for wages paid to less-educated natives.

[1] Manacorda et. al. (2006) find similar imperfect substitutability between native and immigrant workers for the UK. Other important contributions to the literature on immigration and wages include Altonji and Card (1991), Borjas (1994, 1995, 1999), Borjas, Freeman, and Katz (1997), Butcher and Card (1991), Card (1990), Friedberg and Hunt (1995), Friedberg (2001), and National Research Council (1997).

We begin in Section 2 by describing a simple model of comparative advantage and incomplete specialization of workers. Workers' skill endowments imply that immigration reduces the compensation paid to manual tasks and increases the compensation paid to communication ones. The complementary nature of the two skills and the reallocation of native workers toward communication tasks favor wages paid to native workers. The effects compensate (in part or entirely) for the depressing effect of immigration on the wage paid to manual tasks.

Section 3 describes data for the 50 US states (plus the District of Columbia) from 1960 to 2000 that we use to test our model. Census occupation codes allow us to merge occupational characteristics with individual-level data from the IPUMS Census microdata (Ruggles et. al. (2005)). To measure the manual and communication skill intensity of occupations, we use two separate US Department of Labor datasets on job task requirements – *O*NET* and its predecessor the *Dictionary of Occupational Titles* (*DOT*). *O*NET* measures the importance of several physical (dexterity, coordination, and strength) and language (oral and written comprehension and expression) abilities within each Census occupation code. Data values are based upon experts' recent (post 2000) assessments and therefore reflect the current use of skills across occupations. In contrast, the *DOT* identifies the intensity of skill use in occupations as measured in 1977 and 1991. We use *DOT* data assembled by Autor, Levy, and Murnane (2003) as a robustness check for our *O*NET* results. Unfortunately, this dataset contains only two measures of manual skills (*Eye, Hand, and Foot Coordination* and *Finger Dexterity*). More importantly, the *DOT* variable that comes closest to measuring communication abilities (the performance of *Direction, Control, and Planning* activities) encompasses many tasks in addition to language skills.[2] Though this variable represents a more broadly defined set of "interactive" skills that deviates from our preferred measure of communication intensity, it is likely a close proxy. Despite the limitations of each dataset and skill intensity measure, we are confident in our findings since they are remarkably robust to both dataset choice and estimation strategy.

The empirical analysis in Section 4 strongly supports key implications of our theory. In states with large inflows of less-educated immigrants: i) less-educated native-born workers shifted their supply toward communication tasks at a faster rate than in states with low immigration; ii) the total supply of manual relative to communication skills increased at a faster rate than in states with low immigration; and iii) the compensation paid to manual relative to communication tasks decreased more than in states with low immigration. Less-educated natives have responded to immigration by leaving physically demanding occupations for language-intensive ones. These results are upheld by two stage least squares (2SLS) regressions that instrument for the variation of less-educated immigrants across states using two different sets of exogenous variables, both of which exploit the increased level of Mexican immigration as an exogenous supply shift. The first instrument follows a strategy similar to Card (2001), Card and Di Nardo (2000), and Cortes (2006) by using the imputed share of Mexican workers (based upon 1960 state demographics and subsequent national growth rates) as a proxy for the

[2] The other variables in this dataset pertain to analytical or cognitive skills.

share of less-educated immigrants in a state. The second set of instruments interacts decade indicator variables with the distance of a state's center of gravity to the Mexico-US border, its square, and a border dummy.

Given the positive wage effect of specializing in language-intensive occupations, native-born task reallocation has protected their real wages and mitigated losses due to immigration. In Section 5, we use our model and empirical results to calculate the effect of immigration on average wages paid to native-born workers with a high school degree or less education. Task complementarities and increasing specialization among native-born workers imply that the wage impact of immigration on less-educated natives, while usually negative, is very small for the US overall. While less educated workers in some states such as Arizona and Texas still experience negative wage effects from immigration, in most states those effects are either very small or even positive. Importantly, the impact on different groups of native workers differs depending on their task supply response. We find that groups potentially more threatened by competition with immigrants (such as young or black workers) respond more vigorously in their task specialization, neutralizing a larger part of the negative wage effect. These findings agree in spirit with those of Card (2001), Card and Lewis (2007), and Ottaviano and Peri (2006), while adding a new angle to the structural frameworks used by Borjas (2003), Borjas and Katz (2005), and Ottaviano and Peri (2006) to analyze the effect of immigration.

2 Theoretical Model

We propose a simple general equilibrium model of comparative advantages in task performance to illustrate the effects of immigration on specialization and wages.[3] We briefly describe the model here, and provide more detailed derivations and results in the Appendix. We will test the model's qualitative implications in Section 4, and use its structure and empirically-estimated elasticities to evaluate the effects of immigration on wages paid to less-educated native-born workers in Section 5.

2.1 Production

Consider an open economy (e.g., a US state) that combines two non-tradeable intermediates, Y_H and Y_L, in a CES production function to produce a final tradeable consumption good, Y, according to Equation (1).

$$Y = \left[\beta Y_L^{\frac{\sigma-1}{\sigma}} + (1-\beta) Y_H^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{1}$$

The parameter $\sigma \in (0, \infty)$ measures the elasticity of substitution between the two intermediate goods, while β and $(1-\beta)$ capture the relative productivity of Y_L and Y_H in the production of Y. Y is chosen to be the

[3]Grossman and Rossi-Hansberg (2006) develop an interesting theory of off-shoring that builds upon a process of international task division. Autor and Dorn (2007) use a model of differentiated task performance to analyze the evolution of wages in the 1980s and 1990s related to computer adoption. Those models have features similar to ours.

numeraire, and we assume it is assembled by perfectly competitive firms that minimize costs and earn no profits. This ensures that the prices of Y_L and Y_H (denoted P_L and P_H) are equal to their marginal products.

The two intermediate goods are produced using different skills. Low education workers (with total labor supply equal to L) produce Y_L, and high education workers (H) produce Y_H. While CES production functions combining the services of high and low education labor are widely used in economics,[4] we add to the framework by assuming that less-educated workers must perform two types of tasks (i.e., manual and communication skills) to produce Y_L. Manual tasks require the use of physical skills such as dexterity, bodily coordination, or strength. Communication tasks such as directing, managing, and organizing people requires mostly language skills. Let less-educated workers supply M units of manual-task inputs and C units of communication-task inputs in the aggregate. These tasks combine to produce Y_L according to the CES function in Equation (2), where $\beta_L \in (0,1)$ captures the relative productivity of manual skills and $\theta_L \in (0,\infty)$ measures the elasticity of substitution between M and C.

$$Y_L = \left[\beta_L M^{\frac{\theta_L - 1}{\theta_L}} + (1-\beta_L) C^{\frac{\theta_L - 1}{\theta_L}}\right]^{\frac{\theta_L}{\theta_L - 1}} \tag{2}$$

Since we focus on the market for less-educated workers, we make the simplifying assumption that highly-educated workers only perform one "analytical" task in the production of Y_H. By standardizing the units of analytical tasks, we can simply assume that Y_H is produced according to a linear technology equal to the total supply of highly-educated workers. That is, $Y_H = H$.

Competitive labor markets and perfect competition among producers of Y_L and Y_H yield the relative task demand function in Equation (3), where w_M and w_C denote the compensation (rate of return) paid for one unit of manual and communication task, respectively.

$$\frac{M}{C} = \left(\frac{\beta_L}{1-\beta_L}\right)^{\theta_L} \left(\frac{w_M}{w_C}\right)^{-\theta_L} \tag{3}$$

2.2 Relative Supply of Tasks with Heterogeneous Workers

Since each highly-educated worker is identical from a productive point of view, the wage paid to these workers equals the marginal productivity of Y_H in (1). That is, $W_H = P_H$. In contrast, less-educated workers are heterogeneous and differ from each other in their relative task productivity. In particular, each agent j is characterized by a specific level of effectiveness in performing the two tasks. Let m_j and c_j represent the effectiveness of worker j in performing manual and communication tasks, respectively. The one unit of labor supplied by less-educated worker j can be fully used to provide m_j units of manual tasks or c_j units of communication tasks. Workers

[4] See the literature on cross-country income differences (Acemoglu and Zilibotti (2001), Caselli and Coleman (2006)), technological change (Acemoglu (1998, 2002)), and labor economics (Katz and Murphy (1992), Card and Lemieux (2001)).

with higher effectiveness in a particular task will spend relatively more of their labor endowment performing it, but we assume that decreasing returns imply that an agent will not choose to fully specialize.

Let l_j be the share of personal labor endowment (share of time) worker j spends performing manual tasks so that $1 - l_j$ is the time spent performing communication tasks. Worker j's supply of manual task units is indicated by $\mu_j = (l_j)^{\delta} m_j$, while its supply of communication task units is $\zeta_j = (1 - l_j)^{\delta} c_j$. The parameter $\delta \in (0, 1)$ captures the decreasing returns from performing a single task. Each worker takes the return paid to tasks as given and chooses an allocation of labor between manual and communication tasks to maximize its labor income given in Equation (4).

$$W_{L,j} = (l_j)^{\delta} m_j w_M + (1 - l_j)^{\delta} c_j w_C. \tag{4}$$

By maximizing wages with respect to l_j, we can identify the equilibrium relative supply of manual versus communication task-units for worker j (Equation (5)), which depends positively on relative task compensation and the worker's relative efficiency in performing tasks, (m_j/c_j).[5]

$$\frac{\mu_j}{\zeta_j} = \left(\frac{w_M}{w_C}\right)^{\frac{\delta}{1-\delta}} \left(\frac{m_j}{c_j}\right)^{\frac{1}{1-\delta}} \tag{5}$$

Aggregate task supply simply equals the summation over all less-educated workers. That is, $M = \sum_j \mu_j = L\overline{\mu}$ and $C = \sum_j \zeta_j = L\overline{\zeta}$, where $\overline{\mu}$ and $\overline{\zeta}$ represent the average unit-supply of manual and communication tasks. Aggregate relative task supply (Equation (6)) is then a function of relative wages and the average relative effectiveness of workers (defined in Equation (7)), where $\vartheta_j = (\zeta_j/C)$ is worker $j's$ share in the total supply of communication tasks.

$$\frac{M}{C} = \frac{\sum_j \mu_j}{\sum_j \zeta_j} = \sum_j \vartheta_j \frac{\mu_j}{\zeta_j} = \left(\frac{w_M}{w_C}\right)^{\frac{\delta}{1-\delta}} \overline{\left(\frac{m}{c}\right)}^{\frac{1}{1-\delta}} \tag{6}$$

$$\overline{\left(\frac{m}{c}\right)} = \left[\sum_j \left(\vartheta_j \left(\frac{m_j}{c_j}\right)^{\frac{1}{1-\delta}}\right)\right]^{1-\delta} \tag{7}$$

In equilibrium, relative task provision (Equation (8)) is a positive function of both the relative productivity of the tasks in the production of Y_L and the average relative effectiveness of workers. An increase in β_L raises $\frac{M}{C}$ demand, while an increase in $\overline{\left(\frac{m}{c}\right)}$ raises supply. Relative compensation (Equation (9)) is also a positive function of β_L, but it depends negatively on $\overline{\left(\frac{m}{c}\right)}$; a population that is more effective in manual task performance (on average) would supply more of those tasks, thereby decreasing their relative price.

[5] In practice (and in anticipation of our empirical strategy), workers are likely to select different allocations of their time between manual and communication tasks according to their occupation choice. Thus, we assume each unique allocation represents a different occupation. A worker will choose an occupation with the time allocation $(l, 1 - l)$ that maximizes its wage income, which depends on its relative efficiency (m_j/c_j) of task performance. For given relative wages, there is a one-to-one correspondence between relative efficiency and occupation choice, as well as between relative efficiency and the relative supply of tasks (Equation (5)). Hence, the choice of occupation reveals the comparative advantage of a worker.

$$\frac{M^*}{C^*} = \left(\frac{\beta_L}{1-\beta_L}\right)^{\frac{\delta\theta_L}{(1-\delta)\theta_L+\delta}} \overline{\left(\frac{m}{c}\right)}^{\frac{\theta_L}{(1-\delta)\theta_L+\delta}} \tag{8}$$

$$\frac{w_M^*}{w_C^*} = \left(\frac{\beta_L}{1-\beta_L}\right)^{\frac{(1-\delta)\theta_L}{(1-\delta)\theta_L+\delta}} \overline{\left(\frac{m}{c}\right)}^{-\frac{1}{(1-\delta)\theta_L+\delta}} \tag{9}$$

All workers receive the same relative task compensation in equilibrium. Equation (10) identifies an individual worker's relative supply of tasks, which is positively related to its effectiveness in performing them. In contrast, the average worker's relative effectiveness will negatively affect an individual's supply. This is because a population with higher manual abilities would supply more units of manual tasks and depress its relative wage, thereby inducing the individual to shift supply from manual toward communication tasks.

$$\frac{\mu_j}{\zeta_j} = \left(\frac{\beta_L}{1-\beta_L}\right)^{\frac{\delta\theta_L}{(1-\delta)\theta_L+\delta}} \overline{\left(\frac{m}{c}\right)}^{-\frac{\delta}{[(1-\delta)\theta_L+\delta](1-\delta)}} \left(\frac{m_j}{c_j}\right)^{\frac{1}{1-\delta}} \tag{10}$$

The left panel of Figure 1 illustrates the relative task wage and provision for an economy. Bold lines represent (in logarithmic scale) aggregate relative task supply and demand. Point E_0 identifies the equilibrium corresponding to Equations (8) and (9). Dotted lines to the left and right of the aggregate supply curve represent relative individual task supply for workers j_1 (with low manual effectiveness) and j_2 (high manual effectiveness). The equilibrium supply for each type of worker is identified by the point where its individual supply curve crosses the level of equilibrium compensation (at points 1 and 2, respectively). Intuitively, an increase in β_L would shift aggregate demand to the right, increase the equilibrium relative compensation for manual tasks, and increase the relative supply of manual tasks for each worker. An increase in $\overline{\left(\frac{m}{c}\right)}$ would shift aggregate supply to the left, decrease the relative compensation for manual tasks, and reduce the relative supply of manual tasks for each worker of a given relative effectiveness.

If we assume that workers also spend their entire wage income to consume Y in each period (there is no capital in the model so we assume no saving and investment), the equilibrium compensation values W_H, w_M, and w_C fully determine the income, task supply, and consumption of each agent. Hence, the model is a simple general equilibrium static representation of a state's economy.

2.3 Two Types of Workers: Effects of Immigration on Relative Task Supply and Returns to Tasks

The model in Section 2.2 analyzes average wages and task provision for a single group of heterogenous workers. In this section, we expand the model to incorporate a second heterogenous group that differs from the first only in its average relative task effectiveness $\overline{\left(\frac{m}{c}\right)}$. Suppose the initial group of less-educated "domestic" (or native-born) workers has size L_D and average effectiveness $\overline{\left(\frac{m_D}{c_D}\right)}$. Now allow immigration so that a new group of less-educated "foreign-born" (or immigrant) workers of size L_F and effectiveness $\overline{\left(\frac{m_F}{c_F}\right)}$ enters the labor force. While there is no clear reason for immigrants to be less productive in performing manual tasks, they are certainly not as proficient as natives in communicating with other native-born workers and other tasks that require mastery of the local language. Therefore, we assume $\overline{\left(\frac{m_F}{c_F}\right)} > \overline{\left(\frac{m_D}{c_D}\right)}$ so that foreign-born workers have, on average, comparative advantages in performing manual tasks, while native workers have comparative advantages in performing communication tasks.[6] This assumption allows us to analyze how immigration affects wages and task provision.

Equation (3) continues to describe relative aggregate demand. Equation (11) represents the relative supply of tasks in the economy obtained by summing the skills provided by each group.

$$\frac{M}{C} = \frac{M_F + M_D}{C_F + C_D} = f\frac{M_F}{C_F} + (1-f)\frac{M_D}{C_D} \tag{11}$$

The term $f = C_F/(C_F+C_D) \in [0,1]$ is the share of communication tasks supplied by foreign-born workers. It is a simple monotonically increasing transformation of the foreign-born share of less-educated workers, $L_F/(L_F+L_D)$. Hence, the aggregate relative supply of tasks in the economy is a weighted average of each group's supply, and the weights are closely related to the share of each group in employment. The relative supply for foreign and native-born workers is given by Equation (6), with $\overline{\left(\frac{m_F}{c_F}\right)}$ and $\overline{\left(\frac{m_D}{c_D}\right)}$ substituting for $\overline{\left(\frac{m}{c}\right)}$, respectively. Equation (12) describes the equilibrium relative compensation of tasks when the average manual versus communication task effectiveness of the population equals $\left[f\overline{\left(\frac{m_F}{c_F}\right)}^{\frac{1}{1-\delta}} + (1-f)\overline{\left(\frac{m_D}{c_D}\right)}^{\frac{1}{1-\delta}}\right]^{(1-\delta)}$.

$$\frac{w_M^*}{w_C^*} = \left(\frac{\beta_L}{1-\beta_L}\right)^{\frac{(1-\delta)\theta_L}{(1-\delta)\theta_L+\delta}} \left[f\overline{\left(\frac{m_F}{c_F}\right)}^{\frac{1}{1-\delta}} + (1-f)\overline{\left(\frac{m_D}{c_D}\right)}^{\frac{1}{1-\delta}}\right]^{-\frac{(1-\delta)}{(1-\delta)\theta_L+\delta}} \tag{12}$$

By substituting this wage equilibrium into aggregate relative supply (6) for domestic workers, we find their equilibrium relative provision of tasks (Equation (13)). The weighted average of $\frac{M_D^*}{C_D^*}$ and $\frac{M_F^*}{C_F^*}$ (according to Equation (11)) identifies the equilibrium aggregate relative provision of tasks in Equation (14).

$$\frac{M_D^*}{C_D^*} = \left(\frac{\beta_L}{1-\beta_L}\right)^{\frac{\delta\theta_L}{(1-\delta)\theta_L+\delta}} \left[f\overline{\left(\frac{m_F}{c_F}\right)}^{\frac{1}{1-\delta}} + (1-f)\overline{\left(\frac{m_D}{c_D}\right)}^{\frac{1}{1-\delta}}\right]^{-\frac{\delta}{(1-\delta)\theta_L+\delta}} \overline{\left(\frac{m_D}{c_D}\right)}^{\frac{1}{1-\delta}} \tag{13}$$

$$\frac{M^*}{C^*} = \left(\frac{\beta_L}{1-\beta_L}\right)^{\frac{\delta\theta_L}{(1-\delta)\theta_L+\delta}} \left[f\overline{\left(\frac{m_F}{c_F}\right)}^{\frac{1}{1-\delta}} + (1-f)\overline{\left(\frac{m_D}{c_D}\right)}^{\frac{1}{1-\delta}}\right]^{\frac{(1-\delta)\theta_L}{(1-\delta)\theta_L+\delta}} \tag{14}$$

The right panel of Figure 1 illustrates the equilibrium in an economy with native and foreign-born labor.

[6] We make no formal assumptions regarding whether one group has an absolute advantage in both tasks.

Immigrants' supply is to the right of domestic workers' supply due to their comparative advantage in manual tasks. The overall relative supply (represented by the thickest line in the panel) is a weighted average of the two – the distance of the average supply curve from those of immigrants and domestic workers is proportional to f and $1 - f$, respectively. An increase in the share of foreign-born employment (which would raise f) would shift the overall relative supply closer to that of foreign-born workers. Point E_1 represents the equilibrium with immigrants, while E_0 is the equilibrium with no immigrants. From the comparison of those two equilibria we can state the following four qualitative implications of our model that are proved using equations (12), (13), and (14) in Appendix A.3.

Proposition 1 *The comparative advantage of foreign-born workers in performing manual tasks implies that they supply relatively more manual versus communication tasks than domestic workers provide:* $\frac{M_F}{C_F} > \frac{M_D}{C_D}$.

Proposition 2 *As the foreign-born share of less-educated workers in an economy increases from zero (only domestic workers) to positive values, the supply of manual relative to communication tasks among less-educated native workers* $\left(\frac{M_D^*}{C_D^*}\right)$ *decreases.* (This effect is illustrated in the right panel of Figure 1 by the shift of native workers' relative supply from E_0 to D.)

Proposition 3 *As the foreign-born share of less-educated workers in an economy increases from zero to positive values, the supply of manual relative to communication tasks among less-educated workers overall* $\left(\frac{M^*}{C^*}\right)$ *increases.* (This effect is illustrated by the shift of aggregate workers' relative supply from E_0 to E_1.)

Proposition 4 *As the foreign-born share of less-educated workers in an economy increases from zero to positive values, the compensation paid to manual relative to communication tasks* $\left(\frac{w_M^*}{w_C^*}\right)$ *decreases.* (This effect is also illustrated by the shift from E_0 to E_1.)

These qualitative implications provide the basis for comparing economies differing from each other in the presence of foreign-born workers in our empirical analysis. We first check the validity of the comparative advantage assumption and the inequality expressed Proposition 1. Then we test the qualitative predictions of Propositions 2-4 using data for US states from 1960-2000.

Notice also that an increase in the average relative skill among immigrants, which we take as exogenous, would have very similar effects to those of an increase in the foreign-born share. Specifically, from conditions (12), (13), and (14) one can easily show that a rise in $\overline{\left(\frac{m_F}{c_F}\right)}$ would decrease the compensation paid to manual relative to communication tasks $\left(\frac{w_M^*}{w_C^*}\right)$, decrease the relative supply of these tasks among less-educated native workers $\left(\frac{M_D^*}{C_D^*}\right)$, and increase their relative supply among less-educated workers $\left(\frac{M^*}{C^*}\right)$ overall. Section 3 will demonstrate that the foreign-born share and $\overline{\left(\frac{m_F}{c_F}\right)}$ have been rising together over time and are likely to reinforce each other.

2.4 Effect of Immigration on Real Wages

In addition to establishing the aforementioned qualitative implications for relative task supply and rates of return, our model can also simulate immigration's effect on the average wage of highly-educated and less-educated native-born workers. To do so, we must first estimate the production parameters (particularly σ and θ_L) and immigration's effect on native-born task supply.

Since the equilibrium price of factors and intermediate goods are equal to their marginal productivity from (1) and (2), we can derive the change in wages paid to highly educated workers (W_H) and in the price of the intermediate low-education intensive good (P_L) in response to changes in their supply. These values are computed from Equations (15) and (16), where $\varkappa_H = \left(\frac{W_H H}{Y}\right)$ is the income share paid to highly-educated workers and $(1-\varkappa_H)$ is the share paid to less-educated workers.

$$\frac{\Delta W_H}{W_H} = \frac{\Delta P_H}{P_H} = -\frac{1}{\sigma}\frac{\Delta H}{H} + \frac{1}{\sigma}\left(\varkappa_H \frac{\Delta H}{H} + (1-\varkappa_H)\frac{\Delta Y_L}{Y_L}\right) \tag{15}$$

$$\frac{\Delta P_L}{P_L} = -\frac{1}{\sigma}\frac{\Delta Y_L}{Y_L} + \frac{1}{\sigma}\left(\varkappa_H \frac{\Delta H}{H} + (1-\varkappa_H)\frac{\Delta Y_L}{Y_L}\right) \tag{16}$$

The percentage change in the supply of the intermediate good, $\frac{\Delta Y_L}{Y_L}$, is related to the change in task-supply of less educated workers by Equation (17), where $\varkappa_M = (w_M M / P_L Y_L)$ is the manual task share of wages paid to less-educated workers and $(1-\varkappa_M)$ equals the share compensating communication tasks.[7]

$$\frac{\Delta Y_L}{Y_L} = \frac{w_M \Delta M + w_C \Delta I}{P_L Y_L} = \varkappa_M \frac{\Delta M}{M} + (1-\varkappa_M)\frac{\Delta C}{C} \tag{17}$$

Equation (15) provides a direct measure of immigration's effect on wages of highly-educated native labor. To obtain the effect on wages paid to native less-educated workers, however, we must consider two channels. First, we need to obtain values for the percentage change in compensation to manual $\left(\frac{\Delta w_M}{w_M}\right)$ and communication $\left(\frac{\Delta w_C}{w_C}\right)$ tasks and then weight those changes by the initial (pre-immigration) average task supply of natives ($\overline{\mu}_D$ and $\overline{\zeta}_D$).[8] Second, we need to account for the change in the effective supply of natives' manual and communication tasks due to immigration ($\Delta\overline{\mu}_D$ and $\Delta\overline{\iota_D}$). The wage impact of this reallocation of tasks equals $(\Delta\overline{\mu}_D)\, w_M + \left(\Delta\overline{\zeta}_D\right) w_C$. Altogether, Equation (18) expresses the net effects of immigration on average wages paid to less-educated native-born workers, highlighting the contribution from these two channels.

$$\frac{\Delta \overline{W}_D}{\overline{W}_D} = \underbrace{\frac{\Delta w_M}{w_M}\frac{w_M}{\overline{\overline{W}}_D}\overline{\mu}_D + \frac{\Delta w_C}{w_C}\frac{w_C}{\overline{\overline{W}}_D}\overline{\zeta}_D}_{First\ Channel} + \underbrace{(\Delta\overline{\mu}_D)\frac{w_M}{\overline{\overline{W}}_D} + \left(\Delta\overline{\zeta}_D\right)\frac{w_C}{\overline{\overline{W}}_D}}_{Second\ Channel} \tag{18}$$

[7] See the derivation in Appendix A.4.

[8] Expressions for $\frac{\Delta w_M}{w_M}$ and $\frac{\Delta w_C}{w_C}$ are given by Equations (35) and (36) in Appendix A.4.

Importantly, there are two reasons why this model predicts a less negative (or more positive) wage effect than in models that assume perfect substitution between natives and immigrants within education groups. First, while the impact on manual compensation $\left(\frac{\Delta w_M}{w_M}\right)$ due to the increased supply of manual skills from immigrants is negative and larger in absolute value than the impact on $\frac{\Delta w_C}{w_C}$ (which may be positive for complementarity reasons), it is weighted by the relative task supply of natives. This weight is smaller than the relative supply of the average individual, because the average includes immigrants. Hence, the negative contribution from that term is smaller for less-educated natives than it is for the average less-educated worker. Second, the predicted reallocation of tasks implies that $\Delta\overline{\mu}_D < 0$ and $\Delta\overline{\zeta}_D > 0$ so that if the communication task supply response is larger than the response of manual task supply, and if $\frac{w_M}{\overline{W}_D} < \frac{w_C}{\overline{W}_D}$ (both conditions are theoretically and empirically true), then the second channel would contribute to an increased average wage paid to domestic less-educated workers.

Finally, Expression (18) can be used to evaluate how the wages paid to any sub-group G of less educated workers responds to immigration, as long as we substitute the measures of task supplies and their estimated response to immigration for that group ($\overline{\mu}_G$, $\overline{\zeta}_G$, $\Delta\overline{\mu}_G$, and $\Delta\overline{\zeta}_G$) into the formula. In Section 5, we calculate the impact of immigration on wages paid to less-educated native black workers, female workers, workers below 40 years of age, and workers with no high school experience.

3 Data Description and Preliminary Evidence

This section describes how we construct measures of task supply to test the main implications of the model. The IPUMS dataset by Ruggles et. al. (2005) provides individual-level data on personal characteristics, employment, wages, immigration status, and occupation choice.[9] As consistent with the literature, we identify immigrants as those who are born outside of the United States and were not citizens at birth. To focus on the period of rising immigration and on Census data only, we consider decennial years from 1960 to 2000. We include only non-military wage-earning employees who were between 18 and 65 years of age and had worked at least one week in the year prior to the Census year. Whenever we construct aggregate or average variables, we weight each individual by his/her personal Census weight, multiplied by the number of hours he/she worked in a year.[10] This allows us to differentiate between part-time and full-time work, and to create variable values reflecting the amount of hourly labor individuals actually supply.

Since the immigrant share of employment varies greatly across US states, we adopt states as the econometric unit of analysis.[11] One critique of this approach is that US states are open economies, so the effects of immigra-

[9] Data downloaded on December 13, 2007.

[10] The number of hours worked in a year equals the number of weeks worked in the year (measured by the IPUMS variable *wkswork2* in 1960 and 1970 and *wkswork1* from 1980-2000) times the number of hours usually worked (*hrswork2* in 1960 and 1970 and *uhrswork* subsequently).

[11] Also see Card (2001, 2007), Lewis (2005), Card and Lewis (2007), Cortes (2006), and Kugler and Yuksel (2006).

tion in one state could spill into others through the migration of natives. Section 4.1.5, however, notes that most of the literature (including some of our previous studies) finds little evidence that natives respond to immigration through interstate migration or by exiting employment. Instead, our analysis provides a new explanation for the observed small wage and employment response to immigration across states – native-born workers partly protect themselves from competition with immigrants by specializing in language-intensive occupations.

3.1 Task Variables

We use two datasets to measure the task intensity of each occupation. By merging occupation-specific task values with individuals across Census years, we are able to obtain aggregate task supply measures for natives and immigrants by education level and state over time.

Our first source of information on occupation characteristics comes from the US Department of Labor's *O*NET* abilities survey.[12] Initiated in 2000, this dataset assigns numerical values to describe the importance of 52 distinct employee abilities (which we refer to as "tasks" or "skills") within each SOC (standard occupation classification) occupation. We merge these occupation-specific values to individuals in the 2000 Census using the SOC codes. The arbitrary scale of measurement for the task variables encourages us to convert the values into percentiles. We assume that the 2000 Census is collectively representative of the US workforce, and then rescale each skill variable so that it equals the percentile score representing the relative importance of that skill within an occupation in 2000.[13] Since Census occupation codes vary across years, we then assign these *O*NET* percentile scores to individuals from 1960 to 2000 using the IPUMS variable *occ1990*, which provides an occupational crosswalk over time. The standardization of skill values between zero and one should facilitate a more intuitive interpretation of their percentage changes over time.

We use only a subset of the *O*NET* abilities dataset – eight different measures of physical skill intensity and four measures of language intensity (Table 1 provides a list of the variables used, organized by skill type and sub-type). The remaining *O*NET* ability variables largely pertain to cognitive, analytical, and social dimensions that are not directly related to physical or language skills (and are likely to be more relevant for highly-educated workers). Thus, we do not include them in our analysis.

The second dataset we use is the precursor of *O*NET*, the *Dictionary of Occupational Titles* (*DOT*), which periodically evaluated the tasks required for more than 12,000 occupations. Autor, Levy and Murnane (2003) (hereinafter ALM) organized information about five different skills for each of the two most recent versions (1977 and 1991) and then merged it with Census Occupation Codes (COC) to analyze how the diffusion of computers has altered the task supply of workers from routine to non-routine tasks.[14] We use the ALM crosswalk to match

[12]The survey is publicly available at: http://www.onetcenter.org/

[13]That is, an occupation with a score of 0.02 for a specific skill indicates that only 2% of workers in the US in 2000 were using that skill less often. The distribution of workers in 2000 used to construct percentiles does not weight individuals by hours worked.

[14]We are extremely grateful to David Autor for providing the data, which has also been used recently by Bacolod and Blum

DOT task variable values with individual demographic information in the Censuses from 1960 to 1990. Changes in the Census occupation classification scheme preclude us from matching the ALM data to the 2000 Census, so we instead use CPS data from 1998, 1999, and 2000 to collectively represent 2000.

The advantage of DOT data is that it relies on skill intensity assessed at the time of the data collection. It might therefore more closely represent the skills required for occupations in earlier years (i.e., Census years closer to the survey publication date). The limitation is that ALM only organize five variables. Two address manual skills – *Eye, Hand, and Foot Coordination* (EHF) and *Finger Dexterity* ($FingDex$). ALM describe EHF as the "Ability to move the hand and foot coordinately with each other and in accordance with visual stimuli." It maintains high values in occupations that demand physical precision (including dancers, athletes, and firefighters). High $FingDex$ values occur in jobs requiring intensive use of finger and hand dexterity (such as drivers or tailors). The lowest for both variables occur primarily in white-collar professions.

Though the ALM dataset does not measure communication or language skills directly, their *Direction, Control, and Planning* (DCP) variable measures the broader notion of an occupation's interactive skill content. ALM define DCP as "adaptability to accepting responsibility for the direction, control, or planning of people and activities." The highest DCP values occur for managerial occupations requiring non-routine language and interpersonal skills, while the lowest are found among traditional blue-collar laborers. The remaining two skills used by ALM (*General Education Math* and *Sets Limits, Tolerance, or Standards*) relate more to cognitive and analytical skills, so we do not consider them in our analysis. Finally, we follow a similar approach to ALM by rescaling the task variable values into percentiles based upon the 1960 distribution of workers.[15]

In most of our analysis we use the richer *O*NET* data. Unless noted otherwise, we average all (eight) manual skill measures to obtain the average supply of physical tasks by an individual, μ, and we average all (four) communication skill variables to obtain ζ. Then we calculate M_F and M_D as the aggregate state level supply of manual skills for foreign and native-born workers, respectively. Similarly, C_F and C_D are the state aggregate values of the communication skill variables. Thus, our measures of a group's manual and communication skill supplies are more accurately the supplies inferred by the occupational distribution of that group.[16]

(2006) to analyze skill premia and the gender wage gap, and by Bacolod et al. (2006) to analyze the effect of urban agglomerations on the premium of specific skills. For more details on the construction of the variables, we refer to the Appendix of Autor, Levy and Murnane (2003).

[15]Note that DCP and EHF refer to non-routine tasks (as defined in ALM) and their supply was not directly displaced by the adoption of computer technology. However $FingDex$ is a skill used in routine manual tasks and its supply might have been affected by computer adoption and mechanization. As technological change can still confound the relative supply of tasks we control for it in our empirical analysis.

[16]We also perform regressions using the DOT data for robustness, using the interactive skill value DCP in lieu of an exclusive measure of language skills.

3.2 Aggregate Trends and Stylized Evidence

This section briefly describes how different occupations rank in their use of physical versus language skills according to the *O*NET* task variables. Table 2 lists representative occupations at different deciles of the distribution of relative manual-communication skill intensity. As we might expect, $\frac{M}{C}$ values are lowest among sales representatives, secretaries, and organizational occupations, while drivers, electricians, and builders score among the highest (Table 1A provides values of the relative intensity for all occupations). Table 3 shows the skill intensity for the occupations (with more than 25,000 less-educated workers in each year) maintaining the most extreme skill differentials. It also reports the foreign-born share of workers with a high school degree or less schooling. One striking fact is that the foreign-born share increased an average of four percentage points between 1970 and 2000 in occupations with low manual versus communication task content, while it gained an average 22 percentage points in those with high $\frac{M}{C}$ values. As we only consider less-educated workers, the educational distribution of immigrants cannot explain this large difference.

Figure 2 reports the aggregate relative supply of manual versus communication tasks for less-educated native and foreign-born workers in each decade between 1960 and 2000. First, in accordance with Proposition 1 of Section 2.3, foreign-born workers with a high school degree or less have provided, on average, more manual relative to communication tasks than similarly educated natives did. The exception is in 1960 when immigrants were at a historical minimum and the two groups provided approximately the same level of relative skills. Second, the gap in relative task supply between native and foreign-born workers has increased significantly over time. By 2000, the relative supply among immigrants was 25% higher than among natives. This is due to two phenomena – the increase in the share of recent immigrants among the foreign-born and the increased relative supply of manual tasks by recent immigrants. Third, less-educated native workers have decreased (if only slightly) their $\frac{M}{C}$ supply. This trend is opposite of that among immigrants, suggesting that immigration constituted a significant exogenous change in skill supply rather than a response to modified skill demand. Considering that the share of immigrants among less-educated workers grew substantially during the forty years analyzed, and that immigrants' relative specialization in manual tasks increased, the aggregate trend is consistent with our second proposition. Native-born workers progressively left physical labor occupations and adopted language-intensive ones as immigrants increasingly satisfied the demand for manual skills.

Using the *DOT* variables, Figure 3 shows a different representation of the same phenomenon. This figure plots the foreign-born percentage of workers with a high school education or less for each Census year in occupations with high (above the median) and low (below the median) values of manual versus communication intensity. Two facts emerge. First, occupations with high $\frac{M}{C}$ values have always attracted a larger share of foreign-born workers. Second, this tendency has become much stronger over time so that in 2000, 20% of less-educated workers in high $\frac{M}{C}$ occupations were immigrants, while only 11% were foreign-born in occupations with low relative skill intensity.

Finally, Figure 4 provides stylized evidence on the systematic association between immigration and native workers' behavior across states. It plots the foreign-born share of less-educated workers and the level of manual versus communication tasks supplied by less-educated native workers for each state in 2000. While this does not control for any other factors, the negative correlation is clear and very strong (a coefficient of -0.59 and standard error equal to 0.07). In states with a higher share of immigrants among less-educated workers, native workers performed significantly more communication relative to manual tasks. The empirical analyses of the next sections test whether part of this remarkable difference in specialization of native workers across states is due to immigration and how this might affect wages paid to native-born workers.

4 Empirical Results

Figures 2 and 3 demonstrated the validity of Proposition 1 by confirming that the relative supply of manual versus communication tasks by foreign-born workers at the national level was larger than the relative supply among native workers in each Census year since 1970. This tendency also characterizes the overwhelming majority of US states. Immigrants supplied relatively more physical versus language skills than natives did $\left(\frac{M_F}{C_F} > \frac{M_D}{C_D}\right)$ in 96% of the state-year observations in which more than 5% of less-educated employment was foreign-born. This phenomenon holds for all observations in which more than 10% of less-educated workers was foreign-born.

The remainder of this section tests whether Propositions 2-4 of Section 2.3, which were derived from our comparative advantage assumption, are also valid. Section 4.1.1 assesses the correlation between the foreign-born share of less-educated workers and the relative supply of tasks by native workers across states (Proposition 2). Instrumental variable regressions in Section 4.1.2 show that immigrant inflows cause natives to specialize. Section 4.1.3 performs robustness checks by using the DOT variables and by controlling for exogenous demand factors. Section 4.1.4 analyzes the impact of immigration on the task specialization of specific demographic groups of native workers. Section 4.2 tests the effect of immigration on the aggregate supply of relative tasks across states (Proposition 3), and Section 4.3 quantifies the effects of immigration on the relative compensation of manual and communication tasks (Proposition 4).

4.1 The Native-Born Worker Response to Immigration

4.1.1 Immigration and the Relative Task Supply of Natives

The wage implications of immigration in our theoretical model hinge upon the task-specialization response of domestic workers to the inflow of immigrants. The regressions in this section examine the association between less-educated immigrants and the task supply of similarly educated native workers across states (s) and time (t). We begin by testing the second qualitative implication of Section 2.3 by estimating Equation (19), weighting each observation by total employment (thus accounting for the large variation in labor market size across states).

$$\ln\left(\frac{M_D}{C_D}\right)_{st} = \alpha_s + \tau_t + \gamma\,(Share\_foreign\_L)_{st} + \varepsilon_{st} \tag{19}$$

The relative supply of manual versus communication tasks by less-educated native workers equals $\left(\frac{M_D}{C_D}\right)_{st}$, and $(Share\_foreign\_L)_{st}$ represents the foreign-born share of less-educated employment.[17] We control for year (τ_t) and state (α_s) fixed effects, and ε_{st} represents a non correlated zero-mean disturbance. If γ is negative, then Proposition 2 holds and native-born workers respond to immigration by specializing in occupations less physically demanding but more language intensive.[18] We can go beyond the simple test of Proposition 2, however, and determine whether immigration has a stronger relationship with the average native-born supply of manual ($\overline{\mu}_D$) or communication ($\overline{\zeta}_D$) tasks by separately estimating Equations (20) and (21).[19]

$$\ln\left(\overline{\mu}_D\right)_{st} = \alpha_s^M + \tau_t^M + \gamma^M\,(Share\_foreign\_L)_{st} + \varepsilon_{st}^M \tag{20}$$

$$\ln\left(\overline{\zeta}_D\right)_{st} = \alpha_s^C + \tau_t^C + \gamma^C\,(Share\_foreign\_L)_{st} + \varepsilon_{st}^C \tag{21}$$

We first investigate the relationships in regressions (19), (20), and (21) by least squares. Table 4 presents the estimates of γ, γ^M, and γ^C for different samples and different variable definitions.[20] Columns (1) and (2) use the average of all eight manual and four language ability *O*NET* variables to construct skill supply. Columns (3) and (4) measure manual skills with the dexterity variables, and communication skills with the oral language variables. Columns (5) and (6) include only coordination skills for manual abilities, and written language skills for communication abilities. Finally, Columns (7) and (8) measure manual skills with physical strength, and communication skills with all four language abilities. We use the full sample (fifty states plus D.C. over 1960-2000) in odd numbered specifications. Even numbered specifications exclude California – home to 30% of all immigrants and the largest economy in the sample – to ensure that this outlier is not driving the estimated correlations.

Three important results emerge. First, the estimates of γ uphold Proposition 2. The coefficients are negative,

[17] Throughout the empirical analysis (except when noted), employment is measured in hours. Thus, $(Share\_foreign\_L)_{st}$ measures the foreign-born share of hours worked by less-educated employees. Results from regressions using data weighted by individuals (rather than hours worked) are quite similar and available upon request.

[18] We will verify that this association is causal in the following sections. For example, omitted demand characteristics (such as sector composition or technology) specific to state-year observations might induce spurious correlation. We will address this problem in Sections 4.1.2 and 4.1.3 by devising an instrumental variable strategy and explicitly controlling for sector-driven demand changes and technological growth.

[19] Recall that $\overline{\mu}_D = \frac{M_D}{L_D}$ and $\overline{\zeta}_D = \frac{C_D}{L_D}$.

[20] Note that since $\ln\left(\frac{M_D}{C_D}\right)_{st} = \ln\left(\overline{\mu}_D\right)_{st} - \ln\left(\overline{\zeta}_D\right)_{st}$, it must be also true that $\gamma = \gamma^M - \gamma^C$.

between -0.15 and -0.22, and usually significant at the 5% confidence level. The estimates in Column (1) suggest that a one percentage-point increase in the foreign-born share of less-educated workers is associated with a 0.17% decline in the relative supply of manual versus communication tasks among natives. Second, this decrease is primarily achieved through a rise in the supply of language skills, rather than a fall in natives' supply of physical labor. The estimate of γ^C in Column (1) implies that a one percentage-point increase in the foreign-born share is associated with a significant 0.14% rise in natives' supply of communication tasks. The estimates of γ^M imply that native supply of manual tasks would only decline by 0.03% and the value is not significantly different from zero. A large inflow of immigrants performing manual tasks is associated with increased demand for complementary communication tasks that natives provide. Third, the results are robust – the significant correlations generally do not depend upon the different task definitions and sample selection.

4.1.2 Instrumental Variable Estimation

To argue that our estimates of γ represent the native-born task supply *response* to immigration, we need to ensure that the cross-state variation of less-educated immigrants is mostly driven by supply shifts. One concern is whether unobserved technology and demand factors, which may differ across states due to variation in sector composition, have simultaneously increased the productivity (demand) of communicative tasks and attracted immigrants. To establish causality, we use two sets of instruments that build upon the fact that documented and undocumented Mexican immigration has represented a large share of the increase in the less-educated foreign-born population beginning in the 1970s. This aggregate inflow was largely independent of state-specific demand shocks and can be exploited as an exogenous supply shift if we can differentiate flows across states.

Our first instrument for the share of immigrants among less-educated workers imputes the proportion of Mexican workers within a state based upon exogenous 1960 demography and subsequent national growth rates. This methodology relies upon two facts similarly exploited by Card (2001) and several other analyses of immigration's effect on state or city economies.[21] First, new immigrants – especially those with little education – tend to move to the same areas in which previous immigrants from their source country live.[22] Second, unlike previous waves of immigration, a large proportion of immigrants between 1960 and 2000 came from Mexico. Together, these facts allow us to use the location preferences of Mexicans as factors affecting the supply of foreign-born workers across states and time that are uncorrelated with state-specific demand (productivity).

First, we record the actual share of Mexicans in the employment of state s in 1960 ($sh\_MEX_{s,1960}$), and then assume that the growth rate of the Mexican share of employment between 1960 and year t was equal across states.[23] Thus, Equation (22) imputes shares in year t, where $(1 + g\_MEX)_{1960-t}$ is the growth factor

[21] Also see Cortes (2006), Lewis (2003), Ottaviano and Peri (2006), Ottaviano and Peri (2007), and Saiz (2003).

[22] This is due to information networks between immigrants and their country of origin, as well as to the immigration policy of the US. A documented less-educated immigrant is most likely to come to the US to join a family member.

[23] Figures used to impute the Mexican share of employment are not weighted by hours worked.

of Mexican-born employment nationwide between 1960 and year t, and $(1+g\_US)_{s,1960-t}$ is the growth factor of US-born workers in state s between 1960 and year t. The identification power of the instrument is based on the fact that some states (such as California and Texas) had a larger share of Mexican immigrants in 1960 relative to others. These states will also have larger imputed shares of Mexicans in 1970 through 2000 and, due to the educational composition of this group, will have a larger immigrant share among less-educated workers.

$$\widehat{sh\_MEX}_{s,t} = sh\_MEX_{s,1960}\frac{(1+g\_MEX)_{1960-t}}{(1+g\_US)_{s,1960-t}} \tag{22}$$

Our second set of instruments similarly relies upon the exogenous increase in Mexican immigration but is based upon geography. First, we use the formula for geodesic distance to calculate the distance (in thousands of Kilometers) of each state's population center of gravity (available from the 2000 Census) to its closest section of the Mexican border.[24] Since we already control for state fixed effects in the regressions, we interact the distance variable with four year dummies (from 1970 to 2000). This captures the fact that distance from the border had a larger effect in predicting the inflow of less-educated workers in decades with larger Mexican immigration. Second, we also use a Mexican border dummy interacted with decade indicators to capture the fact that border states had larger inflows of Mexican workers due to undocumented border crossings. Since illegal immigrants are less mobile across states, border states have experienced a particularly large exogenous supply-driven increase of less-educated immigrant workers. Altogether, our second set of instruments includes both the distance and border variables, each interacted with decade indicators.

The first three rows of Table 5 report the two stage least squares estimates of γ, γ^M, and γ^C respectively. In all cases, we use the average manual and communication *O*NET* definitions to construct the task supply variables, and we weight each state observation by its total employment. Columns (1) and (2) use the imputed share of Mexicans as instruments. Columns (3) and (4) instrument with the geographic variables. Columns (5), (6), and (7) use both sets of instruments. Odd number columns use the full sample of states; even number columns exclude California. In Specification (7) we use only men to construct the task supply and foreign-born share variables.[25] The last rows of Table 5 report relevant statistics from the first stage regression. First, the F-test of joint significance of the instruments in explaining the endogenous variable ($Share\_foreign\_L_{st}$) suggests that each set of instruments has strong explanatory power (F-statistics well above 10). Second, the Hausman test of over-identifying restrictions (which can be performed when we use more instruments than endogenous variables) indicates that the exogeneity of instruments can never be rejected at standard levels of significance.[26]

[24] We divide the US-Mexico border in 12 sections and calculate the distance of each center of gravity with each section and then choose the shortest distance for each state.

[25] Table 8 provides a more systematic analysis of the different response between men and women. The two groups respond to immigration similarly.

[26] The value reported in the second to last row is the χ^2 test statistic under the null hypothesis that none of the instruments appear in the second stage regression. The degrees of freedom are given by the difference between the number of instruments and endogenous variables. We have one endogenous variable and either eight or nine instruments: four distance-decade interactions,

The two-stage least squares results in Table 5 strengthen the OLS conclusions of Table 4. The estimates of γ are always negative and significant. They now range between -0.24 and -0.25 for the full sample, and they are as large as -0.46 in regressions that exclude California. The qualitative results are robust, but we prefer Specification (5) since it includes all states and instruments. According to those estimates, natives respond to increases in immigration by significantly raising their communication task supply by 0.18% for each one percentage-point increase in the foreign-born share of less-educated workers (this figure is larger in all other specifications). At the same time they decrease the supply of manual tasks by 0.06% for each percentage-point increase in the foreign-born share. Note that magnitude of the communication task response is bigger than that of the manual response for all specifications. The similarity of the coefficients in Tables 4 and 5, and the fact that the point estimates are larger in instrumental variables regressions, strengthens our conviction that the immigration shock was largely an exogenous shift in the relative supply of skills at the state level to which native workers responded.

4.1.3 Robustness Checks: *DOT* Variables and Controls for Demand Shifts

The *O*NET* data assumes a constant skill content (equal to its value in 2000) for each occupation over time. This does not allow for variation in task intensity across decades due to changes within occupations. *DOT* data provides a partial remedy. We use the *DOT* evaluation of occupational task content in 1977 to measure skills in 1960, 1970, and 1980, and the data collected by the 1991 survey for 1990 and 2000. Hence, changes in task specialization will reflect both changes in occupational choice as well as the change of skill intensity within occupations across time.

Table 6 reports the estimates of γ, γ^M, and γ^C when manual and interactive tasks are measured with the *DOT* variables. Manual skills are represented by *Eye, Hand, and Foot Coordination* in the first three columns, and an average of coordination and dexterity skills in the final three. *Direction, Control, and Planning* serves as a general measure of interactive tasks in lieu of a more specific measure of communication skills in all specifications. We report the weighted least squares estimates (Columns (1) and (4)), the 2SLS estimates instrumenting with the imputed Mexican workers (Columns (2) and (5)), and the 2SLS estimates using all available instruments (Columns (3) and (6)). The last three rows report the F-test of joint significance of the instruments, the Hausman test of over-identifying restrictions (for regressions using more instruments than endogenous variables), and the p-value from the Hausman test.

The estimates of γ in Table 6 strongly confirm the previous findings. The causal effect of an increase in the share of less educated foreign-born workers on the relative manual versus interactive specialization of natives is

four border-decade interactions, and the imputed share of Mexican workers. The last row reports the probability of obtaining the observed value of the test statistic or higher under the null. We cannot reject the null at any level of significance, so the assumption of instrument exogeneity stands. See Wooldridge (2002).

roughly -0.23% (using all instruments). The WLS and the 2SLS estimates are not meaningfully different from each other, the 2SLS estimates are not much different from those of Table 5 column (5), and the decrease in the relative supply largely arises from an increase in interactive skills (always significantly larger than zero) rather than a decrease in manual ones (often small or non significant).

Our period of analysis is associated with large changes in production technologies, particularly in the diffusion of information technologies and computer adoption. Autor, Levy, and Murnane (2003) demonstrate that this change had a large effect in shifting demand from routine to non-routine tasks. Similarly, the increasing importance of advanced services, the demise of manufacturing, and other sector-shifts might have contributed substantially to differences across states in the demand for manual and interactive tasks. In Table 7 we explicitly introduce controls for a state's technology level and sector composition that may have confounded the correlation between immigration and task intensity in our prior analysis.

We begin by including the share of workers (with at most a high school degree) who use a computer at work to control for the diffusion of technology across states. This data is available in the CPS Merged Outgoing Rotation Group Surveys in 1984, 1997 and 2001. We match the 1984 computer data to the 1980 Census data, the 1997 computer-use data to the 1990 Census, and the 2001 computer data to the 2000 CPS. We impute a share of zero for all states in 1970 and 1960 since the personal computer was first introduced in 1981.

Our second control accounts more explicitly for the industrial composition of each state in 1960 and its effect on task demand. We create state-specific indices of manual versus interactive task demand driven by each state's industrial composition, $\left(\frac{M}{C}\right)^{Tech}$, by assuming that the occupational composition of industries and industry-specific employment shocks are uniform across states. First, we calculate the average physical and interactive content among all workers for each industry i in year t from national data and record the corresponding ratio $\left(\frac{M}{C}\right)_{i,t}$. Next, we calculate industry-level national employment growth since 1960, $g_{i,t}$. By assuming that industries grew at their national growth rates regardless of the state in which they are located, we can predict the employment share of industries within each state and year, $\widehat{EmpShare}_{i,s,t}$. Finally, we calculate a state's level of relative task demand, $\left(\frac{M}{C}\right)^{Tech}_{s,t}$, as the average value of each industry's $\left(\frac{M}{C}\right)_{i,t}$ weighted by the predicted employment shares.

$$\widehat{EmpShare}_{i,s,t} = \frac{EmpShare_{i,s,1960} \cdot (1 + g_{i,t})}{\sum_{i=1}^{Ind} EmpShare_{i,s,1960} \cdot (1 + g_{i,t})} \tag{23}$$

$$\left(\frac{M}{C}\right)^{Tech}_{s,t} = \sum_{i=1}^{Ind} \widehat{EmpShare}_{i,s,1960} \cdot \left(\frac{M}{C}\right)_{i,t} \tag{24}$$

To control for technology and sector-driven changes in task intensity, Regressions (1) and (4) in Table 7 include the computer use variable, (2) and (5) use $ln\left(\frac{M}{C}\right)^{Tech}_{s,t}$, and Columns (3) and (6) include both. The first three columns use the *O*NET* measures of skills, while the final three use the *DOT* data. The first row reports the estimate of γ. Our control variables usually have a significant coefficient with the expected sign – computer adoption is associated with lower manual versus interactive task supply among natives, while sector-driven demand shifts are associated with higher values. Importantly, the inclusion of these variables causes the estimates of γ to range between -0.23 and -0.44. Especially when we include both controls, the native task specialization response to immigration seems even stronger than our prior estimates (between -0.37 and -0.41% for an increase of 1% in the share of foreign-born labor). The larger standard errors, however, do not allow us to reject (in most cases) our previous values.

The last two rows of Table 7 decompose the impact of immigration between its effect on the supply of manual and interactive tasks. In most cases the positive impact on the supply of interactive skills (between 0.17 and 0.25) is larger and more significant than the negative effect on physical ones (between -0.07 and -0.20). All together, the results of this section continue to provide evidence for increasing task-specialization. The relative supply of manual versus interactive skills among natives reduce by roughly 0.20% to 0.25% for each one percentage point increase in the foreign-born share of less-educated workers.

4.1.4 Response of Specific Groups of Native-Born Workers

The results in Tables 4-7 assumed homogeneity among US-born workers with a high school education or less. Our approach, however, allows us to identify the effect of immigration on the task specialization of specific demographic groups. If γ varies across these groups, then the wage implications of immigration will vary as well. Table 8 compares estimates of γ, γ_C, and γ_M for groups bifurcated by race (Column (1)), gender (2), age (3), and education level (4). For each comparison, "Group 1" represents the group earning lower wages (blacks, women, younger workers, and workers without high school experience). Except for women, individuals in Group 1 were also more specialized in manual than communication tasks and hence more vulnerable to job competition with immigrants. The first two rows report the weighted least squares estimates of γ for the comparison groups, and the remaining rows report the 2SLS results (using all instruments) for γ, γ_C, and γ_M.

Each of the eight native-born groups in Table 8 responds to immigration by shifting their specialization from manual tasks to communication ones. In most cases, the increase in supply of language skills was more significant and larger than the decrease in supply of physical tasks. Interestingly, both men and women reduce their relative skill supply by 0.26% for every percentage point increase in the foreign-born share. Differences between people with only primary school education and those with high school experience are similarly negligible – both groups exhibit γ values near -0.35. For other comparison groups, differences in the γ estimates are quite large. Younger workers ($\gamma = -0.39$) adjusted their task supply in response to immigration much more than older workers ($\gamma = -0.15$) did. This likely arises due to greater occupational mobility earlier in a person's career, making older workers in manual occupations more vulnerable to competition from immigrants.

More strikingly, black workers respond to immigration by changing their relative task specialization three times more than non-black workers do ($\gamma = -0.77$ versus $\gamma = -0.25$). Blacks were much more specialized in manual tasks in comparison to non-blacks in 1960 and were more susceptible to competition from immigrants. Figure 5 illustrates, however, that less-educated blacks and immigrants have exhibited opposite trends in their relative supply of manual versus communication tasks over time. Foreign-born and native non-black workers supplied approximately the same level of relative skills in 1960, but this was much lower than the amount supplied by native blacks. By 2000, the roles of blacks and immigrants were inverted, and foreign-born workers were providing far more manual versus communication tasks than either native blacks or non-blacks did. The strong response among blacks in moving toward more language-intensive occupations should, at least in part, have shielded them from large negative wage effects.

4.1.5 Native Employment Response

Our analysis finds that the relative supply of manual versus communication tasks among natives decreases in response to increased immigration. We believe that this is likely due to a form of occupational upgrading. One potential alternative, however, is that immigration has simply displaced native workers in physically intensive jobs, leaving only those in language intensive ones. That is, immigrants may have had a negative employment effect on native workers.

Most regional analyses find that immigration generates little to no native employment effect. In a recent note (Peri and Sparber (2008)), we argue that to obtain an unbiased estimate of the potential displacement effect across states (or any geographical unit), one should perform 2SLS estimation of Equation (25).

$$\left(\frac{\Delta L_D}{L_D + L_F}\right)_{st} = \tau_t + \eta \left(\frac{\Delta L_F}{L_D + L_F}\right)_{st} + \varepsilon_{st} \tag{25}$$

This model regresses the change in (inter-Census) native employment (ΔL_D) on the change in foreign-born employment (ΔL_F). Effective instruments should avoid "booming region" effects (which would induce positive correlation due to unobserved positive regional shocks). The parameter η then identifies the effect of immigration on native employment. A significantly negative value implies displacement. Using our 1960-2000 state data we estimate a positive value of η equal to 0.47 (standard error of 0.39) using OLS, and a positive value of 0.40 (with a standard error of 0.50) using 2SLS and all the instruments from Section 4.1.2.

Several previous studies that use specifications akin to (25) also tend to find zero or small positive effects. Cortes (2006) uses a variant of (25) in levels to analyze the link between immigration and employment of less-educated workers across 25 US metropolitan areas between 1980 and 2000. She finds a positive OLS estimate around 0.20 and an IV value near 0.05. Card (2001), who uses population growth in a city-skill group cell as the dependent variable and the inflow rate of immigrants in the same cell as the explanatory variable,[27] always finds positive and sometimes significant effects on the native population (around 0.10). His subsequent IV estimates (using the shift-share instrument to impute the number of immigrants in a cell) often find results similar to those of his OLS regressions. Ottaviano and Peri (2007) aggregate individuals from all skill levels within a state and estimate an impact of immigration on native employment between -0.3 and 0.3 that is never significant (standard errors around 0.3). Card and Lewis (2007) estimate the effect of low skilled Mexican immigrants on native employment. Their Table 6 results find an effect between 0 and 0.5 that is rarely significant. Card's (2007) Specification (2) adopts the total (immigrant and native) change in the less educated population (or employment) as the dependent variable. His estimated coefficient implies a value of slightly η larger than zero.

While many analyses do not find evidence for a displacement effect among the native-born labor force, it is important to study the potential effect for sub-groups as well. Displacement among black workers has been a particular concern. Our 2SLS regression (similar to (25)) of the change in black employment on the change in the share of less-educated immigrants finds a coefficient of -0.01 and standard error of 0.04, thus arguing against a displacement effect among blacks. Another possibility hypothesized by Borjas et. al. (2006), however, is that increased labor market competition has pushed native blacks into illegal activity, crime, and jail. In other words, institutionalization has operated as unemployment in disguise for the black community. This may have selected among the remaining workers only those who could change occupations toward more language-intensive jobs, leaving the others with grim prospects. While we do not explore this channel in detail, we do use the number of blacks living in group quarters (as percentage of less educated workers) as a measure of black institutionalization across states and Census years. Regressing the decadal change of that variable on the change in the share of less educated immigrants (including time fixed effects and using 2SLS) we again find no significant effect.

In sum, previous analyses of immigration have uncovered a puzzling result – immigration simultaneously generates only small wage effects and no employment effects for natives. We believe our article provides an explanation. Native workers adjust through occupation upgrading and task specialization. While the impact of immigration on sub-groups of American workers (and blacks in particular) deserves more research and specific attention, our model and estimates provide a mechanism through which groups might decrease their vulnerability to immigration.

4.2 Immigration and Total Task Supply

The regression specification in (26) provides a test of Proposition 3, which states that the total relative supply of manual versus communication tasks is bigger in economies with a higher share of immigrants. That is, the large relative task supply among immigrants more than compensates for the reduced supply among natives.

[27] See Equation (8), page 39, in Card (2001).

$$\ln\left(\frac{M}{C}\right)_{st} = \alpha_s^{TOT} + \tau_t^{TOT} + \gamma_{TOT}\left(Share\_foreign\_L_{st}\right) + \varepsilon_{st}^{TOT} \tag{26}$$

We obtain $\left(\frac{M}{C}\right)_{st}$ by aggregating the supply of physical and language skills from all less-educated workers in state s and year t. Proposition 3 implies that $\gamma_{TOT} > 0$. However, we can also test how immigration affects the average amount of manual $(\overline{\mu})$ and communication $\left(\overline{\zeta}\right)$ tasks supplied in equilibrium by running two separate regressions with $\ln(\overline{\mu})_{st}$ and $\ln\left(\overline{\zeta}\right)_{st}$ as dependent variables. Analogous to the specifications in (20) and (21), we call these coefficients γ_{TOT}^{M} and γ_{TOT}^{C}.

The first three rows of Table 9 show the parameter estimates of γ_{TOT}, γ_{TOT}^{M}, and γ_{TOT}^{C}. The last three rows show the F-test of significance for the instruments in the first stage and the test of over-identifying restrictions. Manual and communication tasks are measured using varied sets of *O*NET* variables (see column headers) in Columns (1) through (6), while (7) and (8) use *DOT* data. Each OLS (odd columns) and 2SLS (even columns) regression exhibits positive and significant estimates of γ_{TOT}, thus robustly confirming the prediction of Proposition 3. Its value is between 0.35 and 0.4 when using *O*NET* variables, and is near 0.3 when using *DOT* definitions. These positive values arise due to an increase in the average supply of manual tasks (γ_{TOT}^{M} between 0.10 and 0.28) and a decline in communication task supply (γ_{TOT}^{C} between -0.24 and 0). States with large inflows of less-educated immigrants experience significant increases in physical production skills (brought mainly by immigrants) relative to language skills, as predicted by theory.

4.3 Immigration and the Rate of Return to Task Performance

Proposition 4 suggests that by altering the relative supply of skills in a state, immigration decreases the rate of return to manual skills relative to communication ones. In this section, we estimate the relative compensation response to a state's changing task composition. The demand function in Equation (3) for state s during year t implies that Equation (27) describes the relationship between the relative provision of tasks among all less-educated workers $\left(\frac{M}{C}\right)$ and the relative compensation paid to these skills $\left(\frac{w_M}{w_C}\right)$.

$$\ln\left(\frac{w_M}{w_C}\right)_{st} = \ln\left(\frac{\beta_L}{1-\beta_L}\right)_{st} - \frac{1}{\theta_L}\ln\left(\frac{M}{C}\right)_{st} \tag{27}$$

We allow relative productivity (β_L) to vary systematically across states (due to differences in industrial composition) and over time (due to technological change). We also permit a random, zero-mean, idiosyncratic component in relative productivity. Exogenous shifts in the overall relative supply of physical versus language skills across states can identify the coefficient $\frac{1}{\theta_L}$, where θ_L represents the elasticity of substitution between the tasks. Hence we estimate Equation (28) using two stage least squares. Exogenous shifts in the share of foreign-born workers will affect the aggregate relative supply of skills. Hence, we can estimate $\frac{1}{\theta_L}$ by employing the share of foreign-born workers as instrument for $\frac{M}{C}$.

$$\ln\left(\frac{w_M}{w_C}\right)_{st} = \alpha_s^W + \tau_t^W - \frac{1}{\theta_L}\ln\left(\frac{M}{C}\right)_{st} + \varepsilon_{st}^W \tag{28}$$

We cannot directly observe the relative returns to skills, $\frac{w_M}{w_C}$. However, IPUMS contains individual-level data on wages and other characteristics that we can merge with occupational task information. Measurement of w_M and w_C for each state and year requires two steps for each year in our sample. First, we select only workers with at most a high school degree and regress, by year, the logarithm of individual real weekly wages[28] on indicator variables for years of experience (40 indicators from 1 to 40), a gender dummy, and a race dummy (white versus non-white).[29] The residuals of these regressions represent individual wages after controlling for personal characteristics, which we label $\ln(wage\_clean)_{ist}$ for individual i residing in state s in Census year t.

In the second step, we transform the wages into levels and regress them on the occupation-specific measures of manual and communication skills using weighted least squares. We do this using a variety of definitions for the skill variables. We then allow the coefficients on the skill variables to vary across the 51 states so that they capture the price of manual and communication tasks in each state. By separately estimating the second stage regression in Equation (29) for each year, we can identify the state and year-specific wages received for supplying manual $(w_M)_{st}$ and communication $(w_C)_{st}$ tasks.

$$wage\_clean_{ist} = (w_M)_{st} * Manual_{ist} + (w_C)_{ist} * Communication_{ist} + \varepsilon_{ist} \tag{29}$$

Next, we substitute the estimates $\widehat{w_M}_{st}$ and $\widehat{w_C}_{st}$ into Equation (28) to estimate $\frac{1}{\theta_L}$. Table 10 reports the values of $\frac{1}{\theta_L}$ found using different *O*NET* task variable definitions. Columns (1), (3), and (5) report the estimates of $\frac{1}{\theta_L}$ when we exploit the result of Proposition 3 and directly use $Share\_foreign\_L_{st}$ as an instrument for $\ln\left(\frac{M}{C}\right)_{st}$. The instrument is relatively powerful (F-statistic of 20), and we obtain estimates statistically significant at the 1% level between 1.64 and 1.71. To address concerns that $Share\_foreign\_L_{st}$ could be endogenous as well, we also instrument with our geographic variables and the imputed share of Mexicans in Columns (2), (4), and (6). The instruments are a bit weaker but are still a reliable predictor of $\ln\left(\frac{M}{C}\right)_{st}$. The point estimates of $\frac{1}{\theta_L}$ range between 0.96 and 1.55, are consistently around one, and are always very significantly different from zero.

Altogether, the 2SLS estimates imply that the share of foreign-born workers reduces the relative compensation paid to manual versus communication tasks, thus confirming Proposition 4. The estimates in Table 10 suggest the elasticity of substitution (θ_L) ranges between 0.58 and 1.04. Even assuming a value of 1 – at the

[28]Real weekly wages are calculated by dividing the yearly salary income by the number of weeks worked in the year. The nominal figures are converted into real figures using the CPI-U deflator published by the Bureau of Labor Statistics and available at www.bls.gov/cpi.

[29]We also weight each individual by its Census sample weight times hours worked.

high end of our estimated range – manual and communication tasks have a high degree of complementarity. These figures are comparable to commonly estimated values for the elasticity of substitution between labor and capital (usually near 1), or between workers of different education levels (σ, which fall between 1.5 and 2).[30]

5 Simulated Effects of Immigration on Real Wages, 1990-2000

Our empirical analysis suggests that to understand the wage implications of immigration, simulations must account for the adjustment in native-born task supply. We do so by combining the formulas derived in Section 2 with the estimated response of $\overline{\mu}_D$ and $\overline{\zeta}_D$ to immigration from Section 4.1.1 and the elasticity of substitution between tasks (θ_L) from Section 4.3. First, we use Equations (15), (35), and (36) and the changes in H, M, and C due to immigration between 1990 and 2000 to evaluate the effects of immigration on compensation paid to highly-educated workers, manual tasks, and communication skills. Then we combine those results and the estimates of $\Delta\overline{\mu}_D$ and $\Delta\overline{\zeta}_D$ in Equation (18) to find the overall effect of immigration on average wages paid to less-educated natives. In Section 5.1 we use the average task supply ($\overline{\mu}_D$ and $\overline{\zeta}_D$) and estimated response ($\Delta\overline{\mu}_D$ and $\Delta\overline{\zeta}_D$) of all less educated natives by state and decade to obtain an average effect. In Section 5.2 we use the supply and estimated response of particular demographic groups previously analyzed in Table 8.

5.1 Effect on the Average Less-Educated US-Born Worker

The simulated effect of immigration on average wages paid to less-educated native workers in our model differs from the effect in a model of perfectly substitutable native and immigrant labor for two reasons. First, the change in compensation paid to communication skills $\left(\frac{\Delta w_C}{w_C}\right)$ is weighted more heavily, and the change in compensation paid to manual tasks $\left(\frac{\Delta w_M}{w_M}\right)$ less heavily, for natives than for the average population (which includes foreign-born workers). Since immigrants supply more manual tasks, we know that $\frac{\Delta M}{M} > \frac{\Delta C}{C}$. This implies $\frac{\Delta w_M}{w_M}$ (which is usually negative) is smaller than $\frac{\Delta w_C}{w_C}$ (which is sometimes positive). Hence, the loss in compensation from manual tasks is weighted less in occupations chosen by natives. This attenuation grows larger if natives increasingly specialize in language skills, and is stronger in high immigration states. Second, the empirical results suggest that the term $(\Delta\overline{\mu}_D)\frac{w_M}{W_D} + \left(\Delta\overline{\zeta}_D\right)\frac{w_C}{W_D}$ in Equation (18) also positively contributes to the average wage of natives. On one hand, immigration increases $\overline{\zeta}_D$ more significantly than it reduces $\overline{\mu}_D$. Moreover, the unit compensation for physical skills $\left(\frac{w_M}{W_D}\right)$ was 10 to 20 percent smaller than the unit compensation for communication tasks $\left(\frac{w_C}{W_D}\right)$ in 1990 and 2000.[31] This differential was larger in high immigration states so that immigration shifted workers to occupations whose tasks were better compensated. On the other hand, the

[30] See Katz and Murphy (1992) or Angrist (1995).

[31] The estimates of $\widehat{w_M}$ and $\widehat{w_C}$ were obtained in Section 4.3 and are used in this section to calculate the shares of M and C in wages paid to less educated workers, as well as the ratios $\frac{w_C}{W_D}$ and $\frac{w_M}{W_D}$.

estimates from Tables 5, 6, and 7 imply that the positive impact of immigration on $\Delta\overline{\zeta}_D$ was generally larger than the negative impact on $\Delta\overline{\mu}_D$. Hence, higher demand for complementary services also had a positive effect on average wages, shifting natives to jobs with higher communication content.

Table 11 reports the simulated effects of immigration from 1990-2000 at the national level and for the ten states with the highest share of immigrants among their less-educated workforce in 2000 (listed alphabetically). The first two columns report the increase in foreign-born employment (as a percentage of 1990 total group employment) among workers with some college education $\left(\frac{\Delta H}{H}\right)$ and those with high school degree or less $\left(\frac{\Delta L}{L}\right)$, respectively. Notice that for each reported state (except New Jersey and Florida) the percentage inflow of less-educated immigrants during 1990-2000 was larger than the inflow of more-educated ones. For Arizona and Texas the inflow of less-educated was more than three times that of more-educated workers.

Columns (3) through (5) apply the formulas (15), (35), and (36) to obtain the percentage change in wages paid to highly-educated workers $\left(\frac{\Delta \overline{W}_H}{\overline{W}_H}\right)$, manual skills $\left(\frac{\Delta w_M}{w_M}\right)$, and communication tasks $\left(\frac{\Delta w_C}{w_C}\right)$ caused by immigration.[32] Since the inflow of highly-educated immigrants was small relative to the inflow of less-educated ones, the wage effect on people with college education is usually positive (a gain of 1.2% at the national level). The change in returns to manual versus communication tasks caused by immigration is clearly more important for understanding the effects of immigration on less-educated workers. In California, the compensation paid for physical skills performed by less educated workers decreased by 8.4%, while the compensation of language skills increased by 0.3%. In Arizona, the return to manual tasks decreased by 14%, while the wage paid for communication tasks decreased by only 1%. Nationally, the return to manual tasks decreased by 2.8%, while the return to communication tasks increased 1.2%.

The final three columns of Table 11 highlight the ultimate wage consequences of immigration for less-educated native-born workers. Column (6) reports the effect on average wages before accounting for any shift in domestic task supply or for differences in the relative supply of tasks. That is, these figures are useful for identifying the counter-factual wage effects identified by models that assume perfect substitutability between native and foreign-born workers of similar educational attainment. Column (8), by comparison, reports the wage effects for less-educated natives that account for the reallocation of tasks following immigration. Column (7) provides the difference between these values. Thus, this column illustrates the difference in wage effects estimated in our model of comparative advantage versus a traditional one of homogeneous labor. To calculate these figures, we use the formula in (18). We then compute the values of $\Delta\overline{\zeta}_D$ and $\Delta\overline{\mu}_D$ by multiplying the change in the foreign-born share of each state between 1990 and 2000 by the average response of communication and manual task supply to immigration from Column (5) of Table 5 (respectively +0.18 and -0.06). The resulting values are elasticities that, when multiplied by the initial values of task supply, equal $\Delta\overline{\zeta}_D$ and $\Delta\overline{\mu}_D$.

[32] We assume a value of $\sigma = 1.75$ that is in the middle of the range usually estimated in the literature (1.5 to 2). We also set $\theta_L = 1$, a value implying that tasks are more substitutable than most of our estimates find.

By specializing in language skill-intense occupations, less-educated natives reduce wage losses due to immigration. At the national level, specialization causes the wage loss of less-educated native workers to decline by one percentage point (from -1.2% to -0.2%). In states with large immigration (such as California, Arizona, and Nevada) task reallocation reduces the wage loss by around 2.5 percentage points. Specialization changes the effect of immigration on less-educated natives from negative to positive values in three states.

State-level averages still conceal a large degree of variation in wage effects across occupations. Columns (3) and (4) illustrate that immigration is more likely to harm workers who did not move from physical to language–intensive jobs. For instance, less-educated Texas workers in occupations with only manual content would have lost 8.8% of their wage, while workers in jobs only demanding language skills would have gained 2.1%. This shows that less-educated natives protected themselves from most of the negative wage effects of immigration first because they have typically chosen jobs with higher communication requirements than manual content, and second because immigration pushed them to seek such occupations at higher rates.

5.2 Effect on Native Sub-Groups

Table 12 reports the simulated effects of immigration on the four "Group 1" sub-groups of native less-educated workers from Section 4.1.4 that earn especially low average wages (blacks, women, young workers, and workers with only primary school education). The simulations are somewhat simplistic – they assume that groups only differ in their relative supply of manual versus communication tasks and in their supply response to immigration. The estimated changes in task supply ($\Delta\overline{\zeta}$ and $\Delta\overline{\mu}$) are obtained using the respective 2SLS estimates in Table 8. Intuitively, those groups for which the response to immigration was stronger are those that protected their wages more from competition with immigrants.

Black workers exhibited the greatest skill response and protected their wages most effectively. Though still losing 2.9% of their real wages in Arizona, the simulated effect for black workers gives them a positive wage effect in seven of the ten states considered and a gain of 0.9% at the national level. While black workers might have been more exposed to competition with immigrants simply because the percentage of blacks among less-educated workers is large, and in some states the negative wage effect was non-trivial, we find that they switched their task supply in greater magnitude because they were more threatened by competition with immigrants.

Skill upgrading and wage protection also occurred among young workers and those with only primary education. Workers under 40 years old experienced no wage impact nationally and the wage effects are between 0.5 and 0.9 percentage points less negative in each state than for the average less-educated native worker.[33] Workers with eight years or less education gained in six of the ten states with a positive 0.3% gain nationally. Women, on the other hand, experienced negative consequences more than other low wage earning groups did

[33] Note that part of the response among blacks may be due to their comparatively low average age.

because their task supply was relatively static. The female task response and wage impact is very close to the average effect among all native-born less-educated workers.

6 Conclusions

The effects of immigration on wages paid to native-born workers with low levels of educational attainment depend upon two critical factors. The first is whether immigrants take jobs similar to those of native workers or instead take differing jobs due to inherent comparative advantages between native and foreign-born employees in performing particular productive tasks. The second is whether US-born workers respond to immigration and adjust their occupation choices to shield themselves from competition with immigrant labor.

This paper provides a simple and new theoretical framework and empirical evidence to analyze these issues. We argue that production combines different labor skills. Immigrants with little educational attainment have a comparative advantage in manual and physical tasks, while natives of similar levels of education have a comparative advantage in communication and language-intensive tasks. Native and foreign-born workers specialize accordingly. When immigration generates large increases in manual task supply, the relative compensation paid to communication skills rises, thereby rewarding natives who progressively move to language-intensive jobs.

Our empirical analysis used *O*NET* data and *DOT* information to measure the task-content of occupations in the United States between 1960 and 2000. We find strong evidence supporting the implications of our theoretical model. On average, less-educated immigrants supplied more manual relative to communication tasks than natives supplied. In states with large immigration among the less-educated labor force, native workers shifted to occupations intensive in language skills, thereby reducing native workers' relative supply of manual versus communication tasks. There is a larger relative supply of manual versus communication tasks in states with high levels of immigration. This implies that immigrants more than compensate for the change in skill supply among natives, and it ensures that manual task-intensive occupations earn lower wages.

Since native-born workers respond to inflows of immigrant labor by specializing in occupations demanding language skills, the relative supply of communication tasks by the average US-born worker has increased significantly in the recent decades. As a consequence, the wage loss of less-educated native workers in states with large immigration was significantly smaller than predicted by models in which the labor supplied by less-educated natives and immigrants is perfectly substitutable. In particular, we estimate that immigration of less-educated workers only reduced average real wages paid to less-educated US-born workers by 0.2% between 1990 and 2000. Without task specialization, that loss would have equaled 1.2%.

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A Appendix – Derivation of Equations from Section 2

A.1 Equations from Section 2.1

Competitive labor markets and producers of Y_L and Y_H generate equilibrium conditions for relative input prices and task compensation. By equating the marginal productivity of intermediate goods to their prices, we find the relationship between the relative price of intermediate goods and their relative demand in Equation (30). Equating the productivity of each task to its compensation produces Equation (3).

$$\frac{P_H}{P_L} = \frac{(1-\beta)}{\beta}\left(\frac{H}{Y_L}\right)^{-\frac{1}{\sigma}} \tag{30}$$

A.2 Equations from Section 2.2

Maximization of $W_{L,j}$ with respect to l_j in Equation (4) generates the optimal relative allocation of labor for worker j in Equation (31). By rearranging the definitions of unit-task supply and substituting them into this expression, we can identify an individual's equilibrium relative supply of task units in Equation (5).

$$\frac{l_j}{1-l_j} = \left(\frac{c_j w_C}{m_j w_M}\right)^{\frac{1}{\delta-1}} \tag{31}$$

A.3 Details and Proof of Qualitative Implications

In Section 2.3 we obtained the equilibrium relative compensation of tasks (12) by substituting (6) for domestic and foreign workers into (11), and then equating it with the demand curve (3). Intuitively, this is the wage obtained when the average manual versus communication task effectiveness of the population equals $\left[f\overline{\left(\frac{m_F}{c_F}\right)^{\frac{1}{1-\delta}}} + (1-f)\overline{\left(\frac{m_D}{c_D}\right)^{\frac{1}{1-\delta}}}\right]^{(1-\delta)}$.

The four qualitative implications of the model are listed below with their respective proofs.

1. The comparative advantage of foreign-born workers in performing manual tasks, $\overline{\left(\frac{m_F}{c_F}\right)} > \overline{\left(\frac{m_D}{c_D}\right)}$, implies that they supply relatively more manual versus communication tasks than domestic workers provide. That is, $\frac{M_F}{C_F} > \frac{M_D}{C_D}$.

Proof: Consider individual supply (10) for the average immigrant and domestic worker. The two expressions will share the term $\left(\frac{\beta_L}{1-\beta_L}\right)^{\frac{\theta_L\delta}{(1-\delta)\theta_L+\delta}}\overline{\left(\frac{m}{c}\right)}^{-\frac{\delta}{[(1-\delta)\theta_L+\delta](1-\delta)}}$, but the comparative advantage assumption implies $\overline{\left(\frac{m_F}{c_F}\right)^{\frac{1}{1-\delta}}} > \overline{\left(\frac{m_D}{c_D}\right)^{\frac{1}{1-\delta}}}$. Therefore, $\frac{\overline{\mu}_F}{\overline{\zeta}_F} > \frac{\overline{\mu}_D}{\overline{\zeta}_D}$. Multiplying the numerator and the denominator of the first ratio by L_F, and the numerator and the denominator of the second ratio by L_D we obtain $\frac{M_F}{C_F} > \frac{M_D}{C_D}$. *QED.*

2. A higher foreign-born share (s) of less-educated workers in an economy induces lower aggregate supply of manual relative to communication tasks among less-educated native workers, $\frac{M_D^*}{C_D^*}$.

Proof: Consider Equation (13). The assumption $\overline{\left(\frac{m_F}{c_F}\right)} > \overline{\left(\frac{m_D}{c_D}\right)}$ implies that $\left[f\overline{\left(\frac{m_F}{c_F}\right)}^{\frac{1}{1-\delta}} + (1-f)\overline{\left(\frac{m_D}{c_D}\right)}^{\frac{1}{1-\delta}}\right]$ is monotonically increasing in f. Since f depends positively on s (specifically, $\partial f/\partial s = \frac{\overline{\zeta}_F \overline{\zeta}_D}{(s\overline{\zeta}_F + (1-s)\overline{\zeta}_D)^2} > 0$), the expression in square brackets is increasing in s. Since this expression is raised to a negative power $\left(-\frac{\delta}{(1-\delta)\theta_L+\delta}\right)$ and is the only portion of (13) that depends upon s, it implies that $\frac{M_D^*}{C_D^*}$ is a negative function of s. QED.

3. A higher foreign-born share (s) of less-educated workers in an economy induces a larger supply of manual relative to communication tasks among less-educated workers overall, $\frac{M^*}{C^*}$.

Proof: The expression $\left[f\overline{\left(\frac{m_F}{c_F}\right)}^{\frac{1}{1-\delta}} + (1-f)\overline{\left(\frac{m_D}{c_D}\right)}^{\frac{1}{1-\delta}}\right]$ in Equation (14) is monotonically increases in s and raised to a positive power $\left(\frac{(1-\delta)\theta_L}{(1-\delta)\theta_L+\delta}\right)$ so that $\frac{M^*}{C^*}$ depends positively on s. QED.

4. A higher foreign-born share (s) of less-educated workers in an economy induces lower compensation paid to manual relative to communication tasks , $\frac{w_M^*}{w_C^*}$.

Proof: The expression $\left[f\overline{\left(\frac{m_F}{c_F}\right)}^{\frac{1}{1-\delta}} + (1-f)\overline{\left(\frac{m_D}{c_D}\right)}^{\frac{1}{1-\delta}}\right]$ in Equation (12) contains is monotonically increases in s and raised to a negative power $\left(-\frac{(1-\delta)}{(1-\delta)\theta_L+\delta}\right)$ so that $\frac{w_M^*}{w_C^*}$ depends negatively on s. QED.

A.4 Derivation of $\frac{\Delta w_M}{w_M}$, $\frac{\Delta w_C}{w_C}$, and $\frac{\Delta Y_L}{Y_L}$

To isolate the effect of immigration on wages, first substitute (2) into the production function (1) and take the derivative with respect to the inputs M, C, and H to obtain their marginal products.

$$w_M = (\beta_L \beta)\, Y^{\frac{1}{\sigma}} Y_L^{\left(\frac{1}{\theta_L} - \frac{1}{\sigma}\right)} M^{-\frac{1}{\theta_L}} \tag{32}$$

$$w_C = (1-\beta_L)\beta Y^{\frac{1}{\sigma}} Y_L^{\left(\frac{1}{\theta_L} - \frac{1}{\sigma}\right)} C^{-\frac{1}{\theta_L}} \tag{33}$$

$$W_H = P_H = (1-\beta) Y^{\frac{1}{\sigma}} Y_H^{-\frac{1}{\sigma}} \tag{34}$$

Highly-educated workers earn the unit price of the intermediate good they produce. The logarithmic differential of (34) directly measures immigration's effect on highly-educated workers as expressed in (15).

Wages paid to less-educated workers are divided into their task components. The first order effect of immigration is equal to the percentage change in the intermediate good price P_L. Values for $\left(\frac{\Delta w_M}{w_M}\right)$ and $\left(\frac{\Delta w_C}{w_C}\right)$ in Equations (35) and (36) are obtainable from logarithmic differentials of (32) and (33).

$$\frac{\Delta w_M}{w_M} = \frac{1}{\sigma}\left(\varkappa_H \frac{\Delta H}{H} + (1-\varkappa_H)\frac{\Delta Y_L}{Y_L}\right) + \left(\frac{1}{\theta_L} - \frac{1}{\sigma}\right)\frac{\Delta Y_L}{Y_L} - \frac{1}{\theta_L}\frac{\Delta M}{M} \tag{35}$$

$$\frac{\Delta w_C}{w_C} = \frac{1}{\sigma}\left(\varkappa_H \frac{\Delta H}{H} + (1-\varkappa_H)\frac{\Delta Y_L}{Y_L}\right) + \left(\frac{1}{\theta_L} - \frac{1}{\sigma}\right)\frac{\Delta Y_L}{Y_L} - \frac{1}{\theta_L}\frac{\Delta C}{C} \tag{36}$$

Using Equations (35) and (36) we can express the wage effect for less-educated workers at constant specialization by substituting for $\frac{\Delta w_M}{w_M}$ and $\frac{\Delta w_C}{w_C}$ and simplifying to obtain Equation (16).[34]

$$\frac{\Delta \overline{W}_L}{\overline{W}_L} = \frac{\Delta w_M}{w_M}\frac{w_M}{\overline{W}_L}\overline{\mu} + \frac{\Delta w_C}{w_C}\frac{w_C}{\overline{W}_L}\overline{\zeta} = \varkappa_M \frac{\Delta w_M}{w_M} + (1-\varkappa_M)\frac{\Delta w_C}{w_C} \tag{37}$$

Note that (37) represents the average manual and communication wage effects weighted by their respective initial supplies. The total effect of immigration on the average native-born less-educated worker that accounts for (16) as well as for the effect of changing specialization is given by Equation (18) in the main text.

To derive $\frac{\Delta Y_L}{Y_L}$, first note that since Y_L is produced under perfect competition using services of less-educated workers, we know the total income generated in sector Y_L will be distributed to less-educated workers as in Equation (38).

$$P_L Y_L = \overline{W}_L L = w_M M + w_C C \tag{38}$$

This allows us to relate changes in the production of Y_L to small changes of inputs M and C as in Equation (17). The formal proof hinges only on constant returns to scale to M and C in (2). First, re-write Equation (17) by dividing by $P_L Y_L$. Then take the total differential with respect to M and C to find Equation (39).

$$\frac{dY_L}{Y_L} = \frac{d(\frac{w_M}{P_L}\frac{M}{Y_L} + \frac{w_C}{P_L}\frac{C}{Y_L})}{dM}dM + \frac{d(\frac{w_M}{P_L}\frac{M}{Y_L} + \frac{w_C}{P_L}\frac{C}{Y_L})}{dC}dC \tag{39}$$

From the definition of wages we know that $\frac{w_M}{P_L} = \frac{dY_L}{dM}$ and $\frac{w_C}{P_L} = \frac{dY_L}{dC}$. Distributing the differentiation with respect to M and C we can re-write (39) as in (40).

$$\frac{dY_L}{Y_L} = \frac{w_M M}{P_L Y_L}\frac{dM}{M} + \frac{w_C C}{P_L Y_L}\frac{dC}{C} + \left[\frac{d(\frac{dY_L}{dM})}{dM}\frac{M}{Y_L} + \frac{d(\frac{dY_L}{dC})}{dM}\frac{C}{Y_L}\right]dM + \left[\frac{d(\frac{dY_L}{dM})}{dC}\frac{M}{Y_L} + \frac{d(\frac{dY_L}{dC})}{dC}\frac{C}{Y_L}\right]dC \tag{40}$$

Due to constant returns to scale of M and C in Y_L, the expression $\frac{dY_L}{dM}\frac{M}{Y_L} + \frac{dY_L}{dC}\frac{C}{Y_L}$ equals one (Euler Condition). Constant returns also imply that the second derivatives (with respect to M or C), multiplied by the shares $\frac{M}{Y_L}$ and $\frac{C}{Y_L}$, sum to zero. Hence the two terms in brackets equal zero so that (39) reduces to (41).

$$\frac{dY_L}{Y_L} = \frac{w_M M}{P_L Y_L}\frac{dM}{M} + \frac{w_C C}{P_L Y_L}\frac{dC}{C} \tag{41}$$

Finally, we label the term $\frac{w_M M}{P_L Y_L} = \frac{w_M M}{\overline{W}_L L}$ as $\varkappa_M$, and $\frac{w_C C}{P_L Y_L} = \frac{w_C C}{\overline{W}_L L}$ as $(1-\varkappa_M)$. We then use Δ, rather than d, to indicate a small (rather than an infinitesimal) changes to obtain equation (17).

[34] This can be checked by taking the total logarithmic differential of $P_L = \beta Y^{\frac{1}{\sigma}} Y_L^{-\frac{1}{\sigma}}$ with respect to $\frac{\Delta Y_L}{Y_L}$ and $\frac{\Delta H}{H}$.

Tables and Figures

Table 1
Skill (or Task) Types, Sub-Types, and Variables from *O*NET* and the *Dictionary of Occupational Titles* (*DOT*)

Type of Skill	Skill Sub-Type	*O*NET* Variables	*DOT* Variables
Manual (or Physical) Skills	Dexterity	Finger Dexterity Arm-Hand Steadiness Manual Dexterity Wrist-Finger Speed	Finger Dexterity
	Coordination	Multi-Limb Coordination Gross Body Coordination	Eye, Hand, and Foot Coordination
	Strength	Static Strength Dynamic Strength	
Communication (or Language) Skills	Oral	Oral Comprehension Oral Expression	
	Written	Written Comprehension Written Expression	
Communication and Other Interactive Skills			Direction, Control, and Planning

Note: *O*NET* variables come from the *O*NET* abilities survey. *DOT* variables come from Autor, Levy, and Murnane (2003).

Table 2
Relative Manual/Communication Task Content of Representative Occupations, *O*NET* Definitions

Occupation	Manual Intensity Index	Communication Intensity Index	Manual / Communication	M/C Percentile
Management Analysts	0.12	0.93	0.13	0.00
Financial Services Sales Occupations	0.24	0.75	0.32	0.10
Secretaries	0.33	0.82	0.40	0.20
Transportation Ticket and Reservation Agents	0.35	0.69	0.51	0.30
Primary School Teachers	0.49	0.70	0.70	0.40
Production Supervisors or Foremen	0.58	0.65	0.91	0.50
Nursing Aides, Orderlies, & Attendants	0.69	0.55	1.26	0.60
Cashiers	0.74	0.38	1.91	0.70
Truck, Delivery, & Tractor Drivers	0.85	0.29	2.95	0.80
Assemblers of Electrical Equipment	0.70	0.11	6.18	0.90
Drywall Installers	0.67	0.00	268.27	1.00

Note: Authors' calculations are based upon *O*NET* task definitions and the 2000 Census. The occupations included are those at each decile of the 2000 distribution or workers' manual versus communication task intensity. The manual index is constructed averaging eight measures that capture the intensity of use of several physical abilities. The communication task index is constructed averaging four measures that capture oral and written expression and comprehension. Both are standardized to be between 0 and 1. The details of their construction are reported in the main text.

Table 3
Occupations, Relative Task Intensity, and the Foreign-Born Share of Less-Educated Employment

Occupation	Manual Intensity Index	Communication Intensity Index	Manual / Communication	Foreign Born Share of Less-Educated Employment 1970	1980	1990	2000	Increase 1970-2000
Four Occupations with Lowest Manual/Communication Values								
Managers of Properties and Real Estate	0.14	0.74	0.19	14%	11%	12%	14%	0%
Insurance Sales Occupations	0.21	0.81	0.26	4%	3%	4%	6%	2%
Real Estate Sales Occupations	0.24	0.76	0.32	5%	7%	9%	13%	8%
Salespersons, n.e.c.	0.27	0.70	0.38	4%	6%	8%	10%	6%
Four Occupations with Highest Manual/Communication Values								
Gardeners and Groundskeepers	0.82	0.07	11.7	9%	13%	27%	39%	30%
Laborers Outside Construction	0.72	0.05	14.9	6%	9%	15%	16%	10%
Vehicle Washers and Equipment Cleaners	0.72	0.04	19.1	7%	9%	18%	27%	20%
Roofers and Slaters	0.73	0.01	146.7	4%	8%	14%	30%	27%

Note: Authors' calculations based upon *O*NET* task definitions and Census 1970-2000. The occupations included are those with more than 25,000 less-educated employees in each year. Only less-educated wage-earning employees aged between 18 to 65 years old and not living in group quarters are considered. The manual index is constructed averaging eight measures that capture the intensity of several physical abilities. The communication task index is constructed averaging four measures that capture oral and written expression and comprehension. Both are standardized to be between 0 and 1. The details of their construction are reported in the main text.

Table 4
Impact of Foreign-Born Workers on the Native Supply of Tasks, Least Squares Estimates
*Workers with a High School Degree or Less, Different Definitions of Manual and Communication Skills Using O*NET Data*

Explanatory Variable: Foreign-Born Share of Workers with a High School Degree or Less

		Manual: *All Manual Skills* ***Communication:*** *All Communication Skills*		***Manual:*** *Dexterity Skills* ***Communication:*** *Oral Language Skills*		***Manual:*** *Coordination Skills* ***Communication:*** *Written Language Skills*		***Manual:*** *Strength Skills* ***Communication:*** *All Communication Skills*	
Dependent Variable	Parameter	(1) All States	(2) Excluding California	(3) All States	(4) Excluding California	(5) All States	(6) Excluding California	(7) All States	(8) Excluding California
$\ln(M_D/C_D)$	γ	-0.17** (0.06)	-0.22* (0.13)	-0.18** (0.05)	-0.21* (0.12)	-0.15** (0.07)	-0.22 (0.17)	-0.15** (0.06)	-0.20* (0.12)
$\ln(\overline{\mu}_D)$, Manual	γ^M	-0.03 (0.02)	-0.02 (0.04)	-0.06** (0.02)	-0.05 (0.04)	-0.00 (0.02)	0.01 (0.09)	-0.02 (0.02)	-0.02 (0.06)
$\ln(\zeta_D)$, Communication	γ^C	0.14** (0.05)	0.20** (0.09)	0.12** (0.04)	0.16** (0.08)	0.15** (0.06)	0.21** (0.10)	0.13** (0.04)	0.16** (0.08)
Number of Observations		255	250	255	250	255	250	255	250

Note: Each cell contains estimates from a separate regression. The dependent variable in each is indicated in the first column. The explanatory variable is the foreign-born share of less-educated labor. The units of observation in each regression are U.S. states in a Census year (decennial panel of 50 states plus DC from 1960-2000). All regressions include state and year fixed effects. The method of estimation is least squares. Regressions use employment as an analytic weight for each observation, and the standard errors are heteroskedasticity-robust and clustered by state.
** indicates significance at the 5% level * indicates significance at the 10% level

Table 5
Impact of Foreign-Born Workers on the Native Supply of Tasks, 2SLS Estimates
Workers with a High School Degree or Less

Explanatory Variable: Foreign-Born Share of Workers with a High School Degree or Less

		Imputed Mexican Share IV		**Proximity to Mexico IVs**		**All IVs Together**		
Dependent Variable	Parameter	(1) All States	(2) Excluding California	(3) All states	(4) Excluding California	(5) All States	(6) Excluding California	(7) Men Only
$\ln(M_D/C_D)$	γ	-0.25** (0.12)	-0.44** (0.10)	-0.24** (0.10)	-0.46** (0.09)	-0.24** (0.10)	-0.42** (0.10)	-0.25** (0.11)
$\ln(\bar{\mu}_D)$	γ^M	-0.06** (0.03)	-0.09** (0.04)	-0.06** (0.03)	-0.11** (0.02)	-0.06** (0.03)	-0.10** (0.03)	-0.05** (0.02)
$\ln(\bar{\zeta}_D)$	γ^C	0.19** (0.09)	0.32** (0.07)	0.18** (0.08)	0.35** (0.05)	0.18** (0.08)	0.32** (0.07)	0.19** (0.09)
First Stage								
Joint F-Test of the Instruments (p-value)		8.14** (0.006)	49.4** (0.000)	17.96** (0.000)	17.69** (0.000)	14.35** (0.000)	21.04** (0.000)	12.88 (0.000)
Test of Over-Identifying Restrictions (Specification in First Row)		N.A.	N.A.	8.92	7.65	9.18	10	10.2
Probability (χ^2 > test) under the Null of Exogeneity of Instruments		N.A.	N.A.	27%	37%	23%	27%	26%
Number of Observations		255	204	255	204	255	204	204

Note: Each cell contains estimates from separate regressions. The dependent variable in each is indicated in the first column. The explanatory variable is the foreign-born share of less-educated labor. The units of observation in each regression are U.S. states in a Census year (decennial panel of 50 states plus DC from 1960-2000). All regressions include state and year fixed effects. The method of estimation is two stage least squares. Specifications (1)-(2) instrument using the imputed share of Mexicans constructed as described in the main text. Specifications (3)-(4) instrument using the distance between the center of gravity of the state and the Mexican border and a dummy equal to one for states on the Mexican border, all interacted with four decade dummies. Specifications (5) and (6) use all instrumental variables together. Regressions use employment as an analytic weight for each observation, and the standard errors are heteroskedasticity-robust and clustered by state.

** indicates significance at the 5% level

Table 6
Impact of Foreign-Born Workers on the Native Supply of Tasks, Measured by *DOT* Variables

Explanatory Variable: Foreign-Born Share of Less-Educated Workers							
Description of DOT Skill Measures:		***Manual:*** *Coordination Skills* ***Interactive:*** *Direction, Control, and Planning*			***Manual:*** *Coordination and Dexterity Skills* ***Interactive:*** *Direction, Control, and Planning*		
Dependent Variable	Parameter	(1) LS	(2) 2SLS Imputed Mexican Share	(3) 2SLS All IVs	(4) LS	(5) 2SLS Imputed Mexican Share	(6) 2SLS All IVs
Ln($Manual_D$ / $Interactive_D$)	γ	-0.22** (0.06)	-0.16** (0.06)	-0.23** (0.07)	-0.27** (0.05)	-0.19** (0.05)	-0.23** (0.05)
Ln($\bar{\mu}_D$)	γ^M	-0.02 (0.03)	-0.06 (0.06)	-0.11* (0.06)	-0.07** (0.03)	-0.10 (0.03)	-0.11** (0.02)
Ln($\bar{\zeta}_D$)	γ^C	0.20** (0.06)	0.09** (0.04)	0.12** (0.03)	0.20** (0.06)	0.09** (0.04)	0.12** (0.03)
First Stage							
Joint F-Test of the Instruments (p-value)		NA	8.39** (0.005)	15.10** (0.000)	NA	8.39** (0.005)	15.10** (0.000)
Test of Over-Identifying Restrictions (Specification in First Row)		NA	NA	7.65	NA	NA	7.65
Probability (χ^2 > test) under the Null of Exogeneity of Instruments		NA	NA	43%	NA	NA	43%
Number of Observations		255	255	255	255	255	255

Note: Each cell contains estimates from separate regressions. The dependent variable in each is indicated in the first column. Interactive skills are used in lieu of communication data, which *DOT* data does not provide. The explanatory variable is the foreign-born share of less-educated labor measured as hours worked. The units of observation in each regression are U.S. states in a Census year (decennial panel of 50 states plus DC from 1960-2000). All regressions include state and year fixed effects. Regressions use employment as an analytic weight for each observation, and the standard errors are heteroskedasticity-robust and clustered by state. The last two rows report the Hausman test of overidentifying restrictions that can be performed when we use more instruments than endogenous variables. We report the test statistic and the p-value, namely the probability that χ^2 is larger than the observed statistic under the null hypothesis of the exogeneity of the instruments.
** indicates significance at the 5% level

Table 7
Controlling for Technology and Demand Factors

Dependent Variable: Relative Task Supply among Domestic Workers, Ln ($Manual_D$ /$Communication_D$)						
	*O*NET Measures* ***Manual:*** *All Manual Skills* ***Communication:*** *All Communication Skills*			*DOT Measures* ***Manual:*** *Eye, Hand, and Foot Coordination* ***Interactive:*** *Direction, Control, and Planning*		
Explanatory Variables	(1) 2SLS All Instruments	(2) 2SLS All Instruments	(3) 2SLS All Instruments	(4) 2SLS All Instruments	(5) 2SLS All Instruments	(6) 2SLS All Instruments
Foreign-Born Share of Less-Educated Employment	-0.35** (0.11)	-0.23** (0.08)	-0.37** (0.12)	-0.31** (0.08)	-0.31** (0.09)	-0.44** (0.08)
Percentage of Workers Using a Computer	-0.54* (0.16)		-0.10 (0.18)	-0.38** (0.12)		-0.54** (0.11)
Sector-Driven Manual/Communication Task Intensity		0.03 (0.11)	0.56** (0.16)		0.57** (0.13)	0.72** (0.11)
Decomposition of the Effect between Manual and Communication Tasks						
Effect of Foreign-Born Share on Ln($\bar{\mu}$)	-0.10** (0.03)	-0.07** (0.03)	-0.12** (0.03)	-0.17** (0.08)	-0.12** (0.07)	-0.20** (0.08)
Effect of Foreign-Born Share on Ln($\bar{\zeta}$)	0.25** (0.08)	0.17** (0.08)	0.25** (0.09)	0.14** (0.06)	0.18** (0.03)	0.23** (0.06)
Number of Observations	255	255	255	255	255	255

Note: The top three rows report estimates of the impact of the foreign-born share, percentage of computer users, and industry-driven change in relative task intensity on the relative task supply of natives. The bottom two rows report the effect of immigration on the supply of manual and communication tasks separately. The units of observation in each regression are U.S. states in a Census year (decennial panel of 50 states plus DC from 1960-2000) for a total of 255 observations. All regressions include state and year fixed effects. The method of estimation is two stage least squares. Regressions use employment as an analytic weight for each observation, and the standard errors are heteroskedasticity-robust and clustered by state.
** indicates significance at the 5% level

Table 8
Impact of Foreign-Born Workers on the Supply of Tasks among Different Demographic Groups of US-Born Workers with a High School Degree or Less Education

Explanatory Variable: Foreign-Born Share of Workers with a High School Degree or Less Education

Dependent Variable: (Domestic Workers Only)	Parameter	Group 1: Blacks Group2: Non-Blacks	Group 1: Women Group 2: Men	Group 1: Young (18-40) Group 2: Old (41-65)	Group 1: Primary School Only Group 2: Some High School
OLS					
Group 1, *Ln*(M_D/C_D)	γ	-0.71**	-0.24**	-0.26**	-0.27**
		(0.13)	(0.09)	(0.07)	(0.10)
Group 2, *Ln*(M_D/C_D)	γ	-0.15*	-0.17**	-0.14**	-0.30**
		(0.07)	(0.06)	(0.06)	(0.05)
2SLS					
Group 1, *Ln*(M_D/C_D)	γ	-0.77**	-0.26**	-0.39**	-0.34**
		(0.14)	(0.07)	(0.15)	(0.11)
Group 1, *Ln*(M_D)	γ_M	-0.21**	-0.06**	-0.11**	-0.06**
		(0.04)	(0.03)	(0.04)	(0.04)
Group 1, *Ln*(C_D)	γ_C	0.56**	0.19**	0.28**	0.28**
		(0.09)	(0.04)	(0.10)	(0.06)
Group 2, *Ln*(M_D/C_D)	γ	-0.25**	-0.25**	-0.15**	-0.36**
		(0.11)	(0.11)	(0.06)	(0.05)
Group 2, *Ln*(M_D)	γ_M	-0.07**	-0.05**	-0.03	-0.10**
		(0.02)	(0.02)	(0.02)	(0.01)
Group 2, *Ln*(C_D)	γ_C	0.18**	0.20**	0.12**	0.26**
		(0.09)	(0.09)	(0.05)	(0.04)
Number of Observations		255	255	255	255

Note: Each cell contains estimates from separate regressions. Working individuals with a high school degree or less are included. The dependent variable is calculated for specific demographic groups. In each comparison, Group 1 earns lower wages than Group 2 does. The units of observation in each regression are U.S. states in a Census year (decennial panel of 50 states plus DC from 1960-2000) for a total of 255 observations. All regressions include state and year fixed effects. The method of estimation is OLS in the first two rows and two stage least squares using all instruments in the remaining rows. Regressions use employment as an analytic weight for each observation, and the standard errors are heteroskedasticity-robust and clustered by state.

** indicates significance at the 5% level

Table 9
Impact of Foreign-Born Workers on the Total Supply of Tasks

Explanatory Variable: Foreign-Born Share of Less-Educated Workers

		*O*NET Measures*						*DOT Measures*	
		Manual: *All Manual Skills* ***Communication:*** *All Communication Skills*		***Manual:*** *Dexterity Skills* ***Communication:*** *Oral Language Skills*		***Manual:*** *Strength Skills* ***Communication:*** *All Communication Skills*		***Manual:*** *Eye, Hand, and Foot Coordination* ***Interactive:*** *Direction, Control, and Planning*	
Dependent Variable	Parameter	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS	(5) OLS	(6) 2SLS	(7) OLS	(8) 2SLS
All Workers Ln(M/C)	γ_{TOT}	0.37** (0.10)	0.37** (0.12)	0.34** (0.09)	0.37** (0.10)	0.40** (0.10)	0.38** (0.15)	0.28** (0.09)	0.29** (0.10)
All Workers Ln($\bar{\mu}$)	γ^{M}_{TOT}	0.14** (0.02)	0.14** (0.03)	0.10** (0.02)	0.11** (0.02)	0.17** (0.03)	0.16** (0.04)	0.28** (0.03)	0.20** (0.08)
All Workers Ln($\bar{\zeta}$)	γ^{C}_{TOT}	-0.23** (0.06)	-0.24** (0.09)	-0.24** (0.07)	-0.26** (0.08)	-0.23** (0.08)	-0.22** (0.10)	0.00 (0.08)	-0.09* (0.04)
First Stage									
Joint F-Test of the Instruments (p-value)		NA	14.35** (0.000)	NA	14.35** (0.000)	NA	14.35** (0.000)	NA	15.01** (0.000)
Test of Over-Identifying Restrictions (Specification in First Row)		NA	6.12	NA	5.86	NA	5.35	NA	4.02
Probability (χ^2 > test) under the Null of Exogeneity of Instruments		NA	64%	NA	67%	NA	72%	NA	85%
Number of Observations		255	255	255	255	255	255	255	255

Note: Each cell contains estimates from separate regressions. The dependent variable in each is indicated in the first column. The explanatory variable is the foreign-born share of less-educated labor. The units of observation in each regression are U.S. states in a Census year (decennial panel of 50 states plus DC from 1960-2000) for a total of 255 observations. All regressions include state and year fixed effects. The method of estimation is OLS or two stage least squares using all instruments. Regressions use employment as an analytic weight for each observation, and the standard errors are heteroskedasticity-robust and clustered by state. The last two rows report the Hausman test of overidentifying restrictions that can be performed when we use more instruments that endogenous variables. We report the test statistic and the p-value, namely the probability that χ^2 is larger than the observed statistic under the null hypothesis of the exogeneity of the instruments. ** indicates significance at the 5% level.

Table 10
Estimates of the Relative Wage Elasticity of Manual versus Communication Tasks

Dependent Variable: Wage Paid to Manual Tasks / Wage Paid to Communication Tasks

	Manual: *All Manual Skills* ***Communication:*** *All Communication Skills*		***Manual:*** *Dexterity Skills* ***Communication:*** *Oral Language Skills*		***Manual:*** *Strength Skills* ***Communication:*** *All Communication Skills*	
Instruments:	*(1) Foreign-Born Share*	*(2) All*	*(3) Foreign-Born Share*	*(4) All*	*(5) Foreign-Born Share*	*(6) All*
$1/\theta_L$	1.71** (0.37)	1.55** (0.33)	1.78** (0.41)	0.96** (0.34)	1.64** (0.35)	1.50** (0.34)
Implied Elasticity of Substitution	**0.58**	**0.65**	**0.56**	**1.04**	**0.61**	**0.66**
F-test of Joint Significance of the Instruments	20.8	17.5	20.8	17.5	20.8	17.5
Observations	255	255	255	255	255	255

Note: The explanatory variable is the negative of the logarithm of the relative supply of manual versus communication tasks among all workers. In Specifications (1), (3), and (5) we use the foreign-born share of less-educated workers as an instrument for the relative supply of manual versus communication tasks in the state. In Specifications (2), (4), and (6), the instrument is the portion of the foreign-born share explained by the geographic variables plus the imputed share of Mexicans. The units of observation in each regression are U.S. states in a Census year (decennial panel of 50 states plus DC from 1960-2000) for a total of 255 observations. All regressions include state and year fixed effects. The method of estimation is two stage least squares. Regressions use employment as an analytic weight for each observation, and the standard errors are heteroskedasticity-robust and clustered by state. The supply of manual and communication tasks is obtained using the different definitions according to the column headers.
** indicates significance at the 5%

Table 11
Foreign-Born Workers and the Simulated Long-Run Effects on Wages and Task Compensation Due to Immigration (1990-2000)

Selected States	(1) Highly-Educated Immigrants (1990-2000), % of Initial Group Size	(2) Less-Educated Immigrants (1990-2000), % of Initial Group Size	(3) Change in Wage of Highly-Educated Workers	(4) Change in Manual Task Return	(5) Change in Communication Task Return	(6) Change in Wage of Less-Educated Natives before Accounting for Complementarities and Specialization	(7) Wage Effect of Task Complementarities and Specialization	(8) Change in Wage Paid to Less-Educated Natives
Arizona	8%	29%	3.2%	-14.2%	-1.3%	**-8.2%**	**2.8%**	**-5.4%**
California	12%	24%	1.5%	-8.4%	0.3%	**-4.5%**	**2.5%**	**-2.0%**
DC	6%	10%	0.5%	-3.3%	-0.4%	**-2.0%**	**2.2%**	**0.2%**
Florida	14%	14%	-0.1%	-2.3%	2.8%	**0.2%**	**1.3%**	**1.5%**
Hawaii	7%	8%	0.1%	-3.4%	4.9%	**-0.3%**	**1.0%**	**0.6%**
Illinois	7%	12%	0.8%	-3.5%	0.7%	**-1.8%**	**1.4%**	**-0.5%**
Nevada	16%	34%	3.5%	-12.0%	1.4%	**-5.8%**	**2.4%**	**-3.4%**
New Jersey	13%	10%	-0.6%	-0.4%	3.7%	**1.6%**	**1.4%**	**3.0%**
New York	10%	13%	0.3%	-2.5%	1.1%	**-0.7%**	**1.8%**	**1.1%**
Texas	8%	22%	2.1%	-8.8%	0.0%	**-4.8%**	**2.0%**	**-2.8%**
United States	6%	9%	0.6%	-2.8%	1.2%	**-1.2%**	**1.0%**	**-0.2%**

Note: The variables and parameters used in the simulations reported above are described in the text. In particular, we assumed σ=1.75 and θ_L=1. The ten states chosen are those with highest foreign-born employment shares among less-educated workers in 2000. The parameters used to estimate the change in supply of each task among native workers in response to immigration are the parameters in Column (5) of Table 5, namely γ^M=0.18 and γ^C =-0.06.

Table 12
Foreign-Born Workers and the Simulated Long-Run Effects on Wages and Task Compensation Due to Immigration (1990-2000), Specific Demographic Groups of Less-Educated Natives

Selected States	(1) Change in Wage of Less-Educated Black Natives	(2) Change in Wage of Less-Educated Native Women	(3) Change in Wage of Less-Educated Natives under 40 Years of Age	(4) Change in Wage of Natives with Primary education only
Arizona	-2.9%	-5.5%	-4.6%	-4.0%
California	1.3%	-2.0%	-1.3%	-0.8%
DC	4.0%	0.2%	1.1%	1.5%
Florida	2.6%	1.5%	2.0%	2.2%
Hawaii	1.9%	0.6%	0.8%	1.1%
Illinois	1.1%	-0.5%	-0.1%	0.3%
Nevada	-1.1%	-3.5%	-2.7%	-2.2%
New Jersey	4.7%	2.9%	3.4%	3.8%
New York	4.1%	1.0%	1.6%	2.0%
Texas	-0.8%	-2.9%	-2.2%	-1.8%
United States	**0.9%**	**-0.3%**	**0.0%**	**0.3%**

Note: The variables and parameters used in the simulations reported above are described in the text. In particular, we assumed σ=1.75 and θ_L=1. The parameters used to estimate the task supply response of each native group to an increase of foreign-born share among less educated are those obtained in Table 8, fourth and fifth row, for each specific group.

Figure 1
Relative Manual/Communication Task Supply and Demand

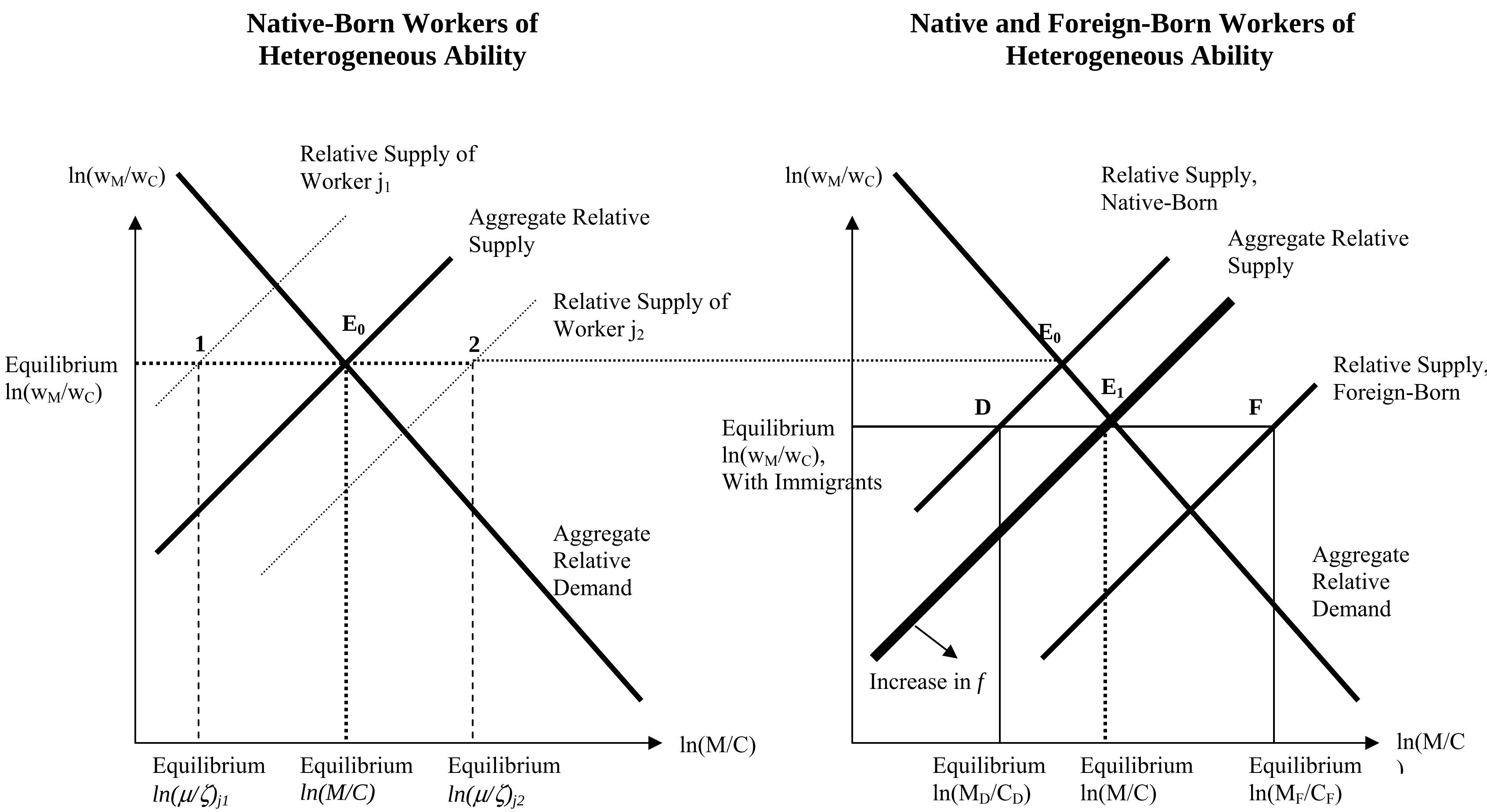


Figure 2
Manual/Communication Intensity of Natives and Immigrants, *O*NET* Measures, 1960-2000
All Workers with a High School Degree or Less Education

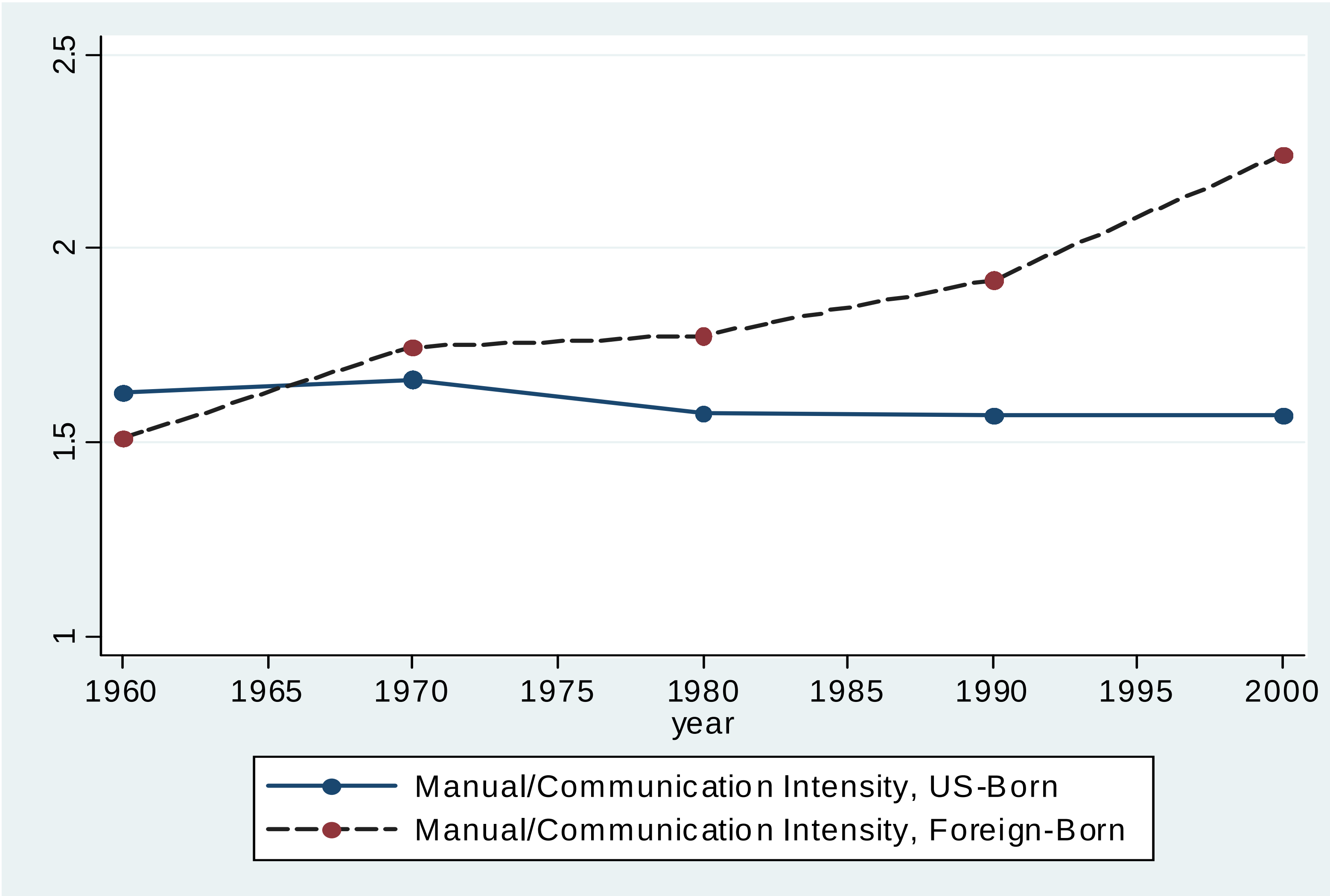


Figure 3
Foreign-Born Share among Occupations with High and Low Levels of Manual/Interactive Intensity, *DOT* Measures, 1960-2000

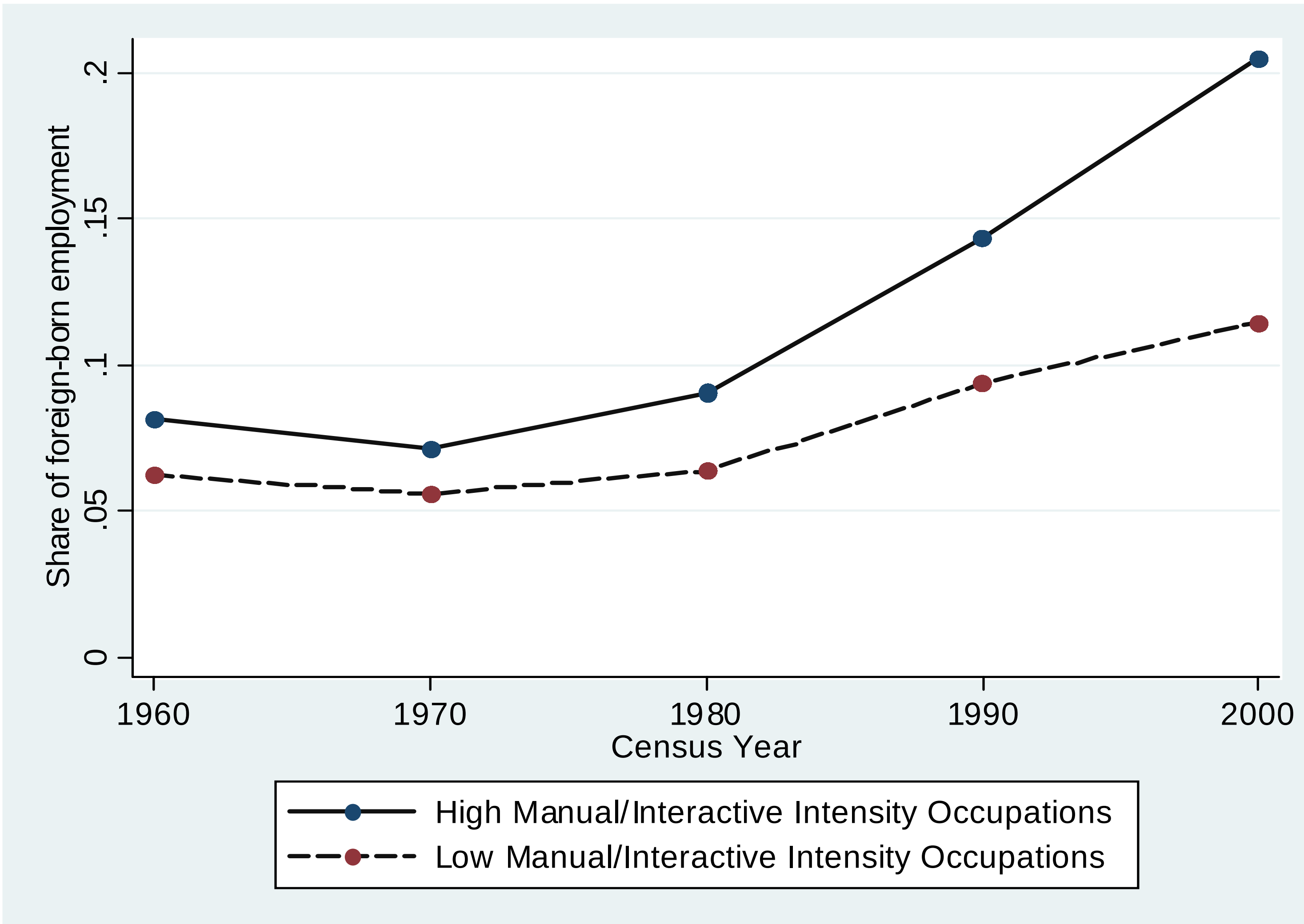
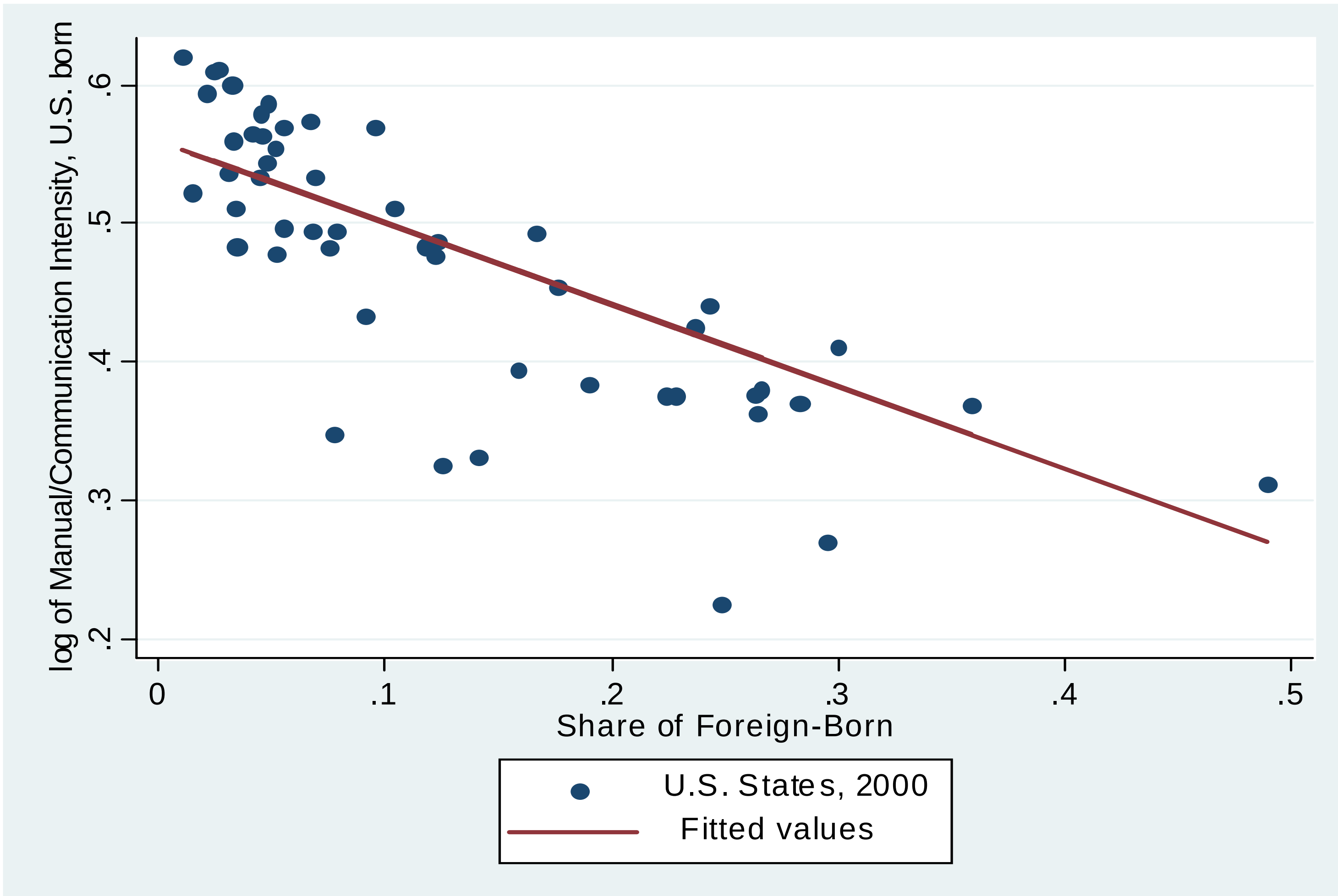
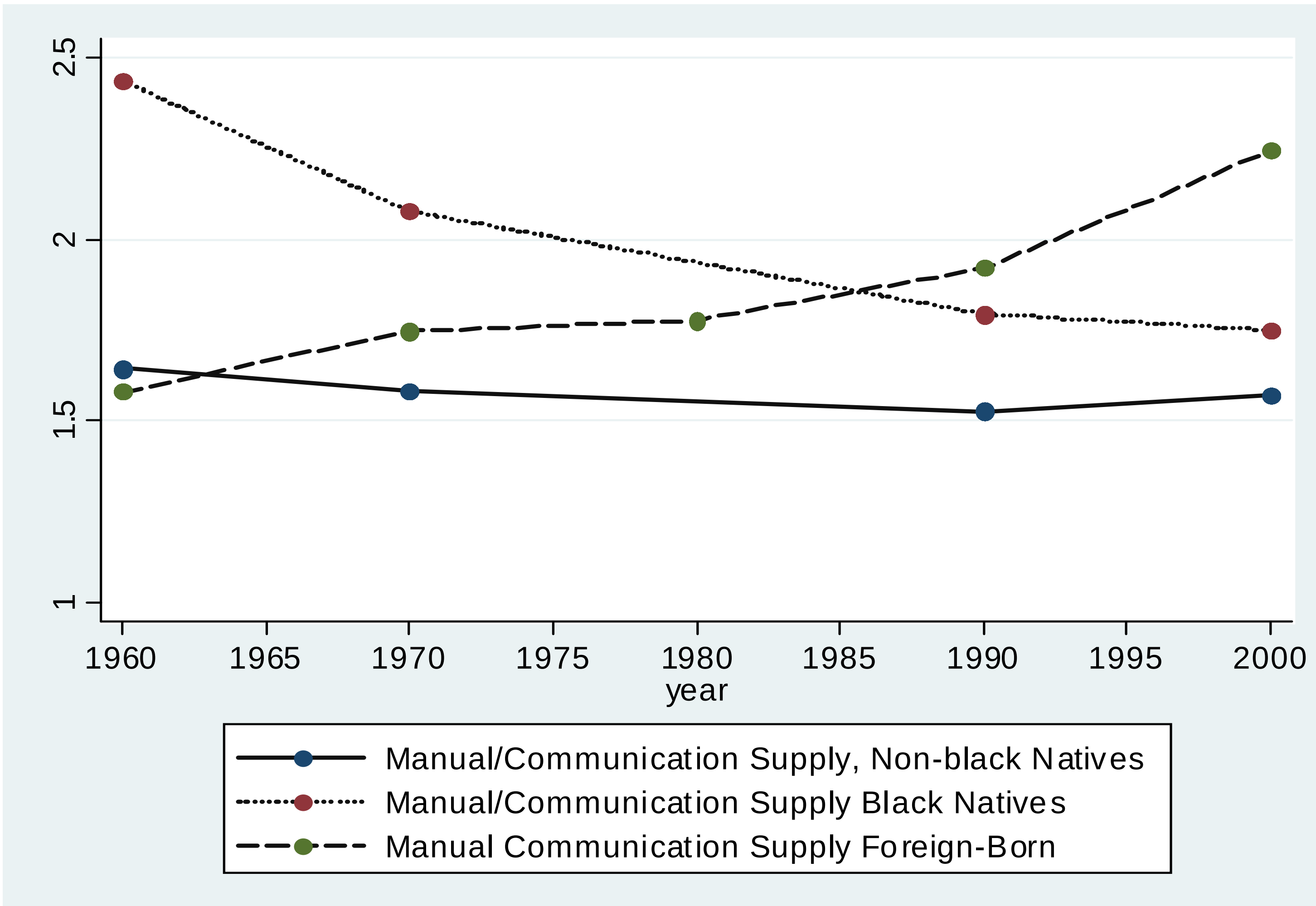


Figure 4
Share of Immigrants and the Relative Manual versus Communication Skill Supply of Natives, U.S. States 2000



OLS slope=-0.59 standard error=0.07

Figure 5
Average Manual versus Communication Supply of Black and Non-Black Natives and Immigrants
*O*NET* Measures, 1960-2000, Workers with a High School Degree or Less Education



Appendix Tables

Table 1A
Relative Manual versus Communication Content of Occupations, *O*NET* Values

M/C	Occupation
0.13	Management analysts
0.13	Psychologists
0.16	Subject instructors (HS/college)
0.17	Business & promotion agents
0.18	Lawyers
0.18	Judges
0.19	Managers of properties & real estate
0.19	Atmospheric & space scientists
0.20	Medical scientists
0.20	Dietitians & nutritionists
0.21	Actuaries
0.21	Economists, market researchers, & survey researchers
0.22	Financial managers
0.22	Operations & systems researchers & analysts
0.22	Physicists & astronomers
0.23	Vocational & educational counselors
0.23	Management support occupations
0.24	Aerospace engineer
0.24	Advertising & related sales jobs
0.25	Proofreaders
0.25	Legislators
0.25	Chief executives & public administrators
0.26	Editors & reporters
0.26	Managers of service organizations, n.e.c.
0.26	Insurance sales occupations
0.28	Technical writers
0.29	Sociologists
0.29	Social scientists, n.e.c.
0.29	Managers of medicine & health occupations
0.29	Social workers
0.30	Managers in education & related fields
0.30	Insurance adjusters, examiners, & investigators
0.30	Mgrs & specialists in marketing, advertising, & PR
0.32	Personnel, HR, training, & labor relations specialists
0.32	Financial services sales occupations
0.32	Other financial specialists
0.32	Real estate sales occupations
0.32	Human resources & labor relations managers
0.33	Writers & authors
0.33	Industrial engineers
0.33	Bill & account collectors
0.34	Clergy & religious workers
0.34	Eligibility clerks for gov't programs; social welfare
0.36	Interviewers, enumerators, & surveyors
0.36	Urban & regional planners
0.38	Human resources clerks, except payroll & timekeeping
0.38	Salespersons, n.e.c.
0.38	Managers & administrators, n.e.c.
0.39	Special education teachers
0.39	Speech therapists
0.39	Hotel clerks
0.39	Sales engineers
0.40	Architects
0.40	Secretaries
0.40	Insurance underwriters
0.40	Postmasters & mail superintendents
0.41	Cust srvc reps, investigators & adjusters, except ins.

M/C	Occupation
0.42	Accountants & auditors
0.42	Actors, directors, producers
0.43	Air traffic controllers
0.43	Mtrl record, schedule, product, plan, & expedite clerks
0.43	Metallurgical & materials engineers, variously phrased
0.44	Purchasing managers, agents & buyers, n.e.c.
0.45	Welfare service aides
0.45	Geologists
0.45	Payroll & timekeeping clerks
0.46	Pharmacists
0.47	Dispatchers
0.47	Legal assistants, paralegals, legal support, etc
0.47	Computer software developers
0.49	Physicians
0.50	Correspondence & order clerks
0.51	Buyers, wholesale & retail trade
0.51	Transportation ticket & reservation agents
0.51	Art/entertainment performers & related
0.51	Announcers
0.52	Mechanical engineers
0.52	Physicians' assistants
0.52	Office supervisors
0.52	Administrative support jobs, n.e.c.
0.52	Agricultural & food scientists
0.52	Chemists
0.53	Statistical clerks
0.53	Computer & peripheral equipment operators
0.53	Records clerks
0.54	Bookkeepers & accounting & auditing clerks
0.55	Inspectors & compliance officers, outside construction
0.55	Petroleum, mining, & geological engineers
0.58	Computer systems analysts & computer scientists
0.60	Statisticians
0.60	Mathematicians & mathematical scientists
0.60	Electrical engineer
0.62	Librarians
0.62	Purchasing agents & buyers, of farm products
0.62	Supervisors of personal service jobs, n.e.c.
0.62	Telephone operators
0.63	Farm managers, except for horticultural farms
0.65	Bank tellers
0.65	Podiatrists
0.65	Occupational therapists
0.66	Billing clerks & related financial records processing
0.67	Funeral directors
0.67	Drafters
0.69	Registered nurses
0.70	Primary school teachers
0.70	Not-elsewhere-classified engineers
0.71	Civil engineers
0.72	General office clerks
0.74	Guards, watchmen, doorkeepers
0.74	Health record tech specialists
0.75	Teachers , n.e.c.
0.75	Receptionists
0.75	Supervisors of motor vehicle transportation
0.76	Biological scientists

Appendix Tables

Table 1A
(Continued)

M/C	Occupation	M/C	Occupation
0.77	Licensed practical nurses	1.53	Waiter/waitress
0.79	Secondary school teachers	1.53	Bartenders
0.81	Data entry keyers	1.54	Weighers, measurers, & checkers
0.82	Inspectors of agricultural products	1.54	Surveyors, cartographers, mapping scientists & tech
0.82	Power plant operators	1.59	Recreation facility attendants
0.82	Managers of food-serving & lodging establishments	1.63	Railroad conductors & yardmasters
0.86	Optometrists	1.66	Taxi cab drivers & chauffeurs
0.86	Supervisors of mechanics & repairers	1.67	Other health & therapy
0.89	Therapists, n.e.c.	1.67	Fire fighting, prevention, & inspection
0.90	Optical goods workers	1.71	Dancers
0.91	Production supervisors or foremen	1.75	Pest control occupations
0.91	Typists	1.77	Shipping & receiving clerks
0.91	Door-to-door sales, street sales, & news vendors	1.78	Retail sales clerks
0.92	Kindergarten & earlier school teachers	1.84	Art makers: paint, sculpt, craft-art, & print-makers
0.92	Supervisors & proprietors of sales jobs	1.91	Cashiers
0.93	Guides	1.91	Motion picture projectionists
0.94	Library assistants	1.94	Elevator installers & repairers
0.96	Supervisors of cleaning & building service	2.06	Postal clerks, excluding mail carriers
0.96	Construction inspectors	2.10	Cooks, variously defined
0.96	Chemical technicians	2.13	Crossing guards & bridge tenders
0.97	Baggage porters	2.22	Repairers of industrial electrical equipment
0.98	Chemical engineers	2.23	Explosives workers
0.98	Health aides, except nursing	2.27	Forge & hammer operators
0.99	Supervisors of construction work	2.28	Kitchen workers
0.99	Foresters & conservation scientists	2.33	Bakers
1.02	Dental assistants	2.33	Messengers
1.02	Personal service occupations, nec	2.35	Electricians
1.02	Technicians, n.e.c.	2.36	Bus drivers
1.03	Child care workers	2.40	Animal caretakers except on farms
1.04	File clerks	2.41	Athletes, sports instructors, & officials
1.04	Veterinarians	2.44	Hairdressers & cosmetologists
1.06	Police, detectives, & private investigators	2.44	Ushers
1.08	Musician or composer	2.44	Photographers
1.09	Respiratory therapists	2.50	Separating, filtering, & clarifying machine operators
1.10	Health technologists & technicians, n.e.c.	2.53	Winding & twisting textile/apparel operatives
1.10	Clinical laboratory technologies & technicians	2.53	Knitters, loopers, & toppers textile operatives
1.15	Other law enforcement: sheriffs, bailiffs, correctional	2.57	Tool & die makers & die setters
1.16	Engineering technicians, n.e.c.	2.59	Photographic process workers
1.17	Physical therapists	2.63	Stock & inventory clerks
1.17	Designers	2.70	Repairers of electrical equipment, n.e.c.
1.20	Archivists & curators	2.72	Roasting & baking machine operators (food)
1.26	Nursing aides, orderlies, & attendants	2.74	Plumbers, pipe fitters, & steamfitters
1.27	Recreation workers	2.75	Mail clerks, outside of post office
1.27	Dentists	2.80	Meter readers
1.27	Airplane pilots & navigators	2.83	Machine operators, n.e.c.
1.28	Supervisors of agricultural occupations	2.84	Dental hygienists
1.29	Dental laboratory & medical appliance technicians	2.84	Repairers of mechanical controls & valves
1.29	Biological technicians	2.87	Automobile mechanics
1.32	Other science technicians	2.89	Boilermakers
1.32	Radiologic tech specialists	2.92	Drilling & boring machine operators
1.34	Repairers of data processing equipment	2.92	Barbers
1.35	Water transport infrastructure tenders & cross guards	2.95	Truck, delivery, & tractor drivers
1.35	Freight, stock, & materials handlers	3.00	Programmers of numerically controlled machine tools
1.37	Protective services, n.e.c.	3.01	Helpers, constructions
1.44	Graders & sorters in manufacturing	3.03	Electric power installers & repairers
1.47	Broadcast equipment operators	3.03	Machinery maintenance occupations
1.52	Public transportation attendants & inspectors	3.05	Timber, logging, & forestry workers

Appendix Tables

Table 1A
(Continued)

M/C	Occupation
3.11	Insulation workers
3.14	Machinists
3.25	Mail & paper handlers
3.26	Mail carriers for postal service
3.28	Packers, fillers, & wrappers
3.31	Sales demonstrators / promoters / models
3.33	Locksmiths & safe repairers
3.34	Batch food makers
3.34	Water & sewage treatment plant operators
3.34	Heating, air conditioning, & refrigeration mechanics
3.35	Telecom & line installers & repairers
3.44	Materials movers: stevedores & long shore workers
3.45	Bus, truck, & stationary engine mechanics
3.45	Other plant & system operators
3.49	Locomotive operators (engineers & firemen)
3.50	Drillers of oil wells
3.51	Railroad brake, coupler, & switch operators
3.54	Shoe repairers
3.54	Parking lot attendants
3.61	Waiter's assistant
3.74	Rollers, roll hands, & finishers of metal
3.76	Printing machine operators, n.e.c.
3.77	Glaziers
3.79	Carpenters
3.84	Sheet metal duct installers
3.89	Garage & service station related occupations
3.96	Ship crews & marine engineers
4.01	Heat treating equipment operators
4.01	Sawing machine operators & sawyers
4.02	Auto body repairers
4.05	Office machine operators, n.e.c.
4.08	Crane, derrick, winch, & hoist operators
4.12	Textile cutting machine operators
4.21	Patternmakers & model makers
4.25	Garbage & recyclable material collectors
4.26	Paving, surfacing, & tamping equipment operators
4.29	Cementing & gluing machine operators
4.30	Heavy equipment & farm equipment mechanics
4.34	Nail & tacking machine operators (woodworking)
4.50	Furnace, kiln, & oven operators, apart from food
4.54	Cabinetmakers & bench carpenters
4.60	Lathe, milling, & turning machine operatives
4.61	Precision grinders & filers
4.81	Paper folding machine operators
4.83	Millwrights
5.28	Lay-out workers
5.28	Other precision & craft workers
5.28	Wood lathe, routing, & planing machine operators
5.39	Farmers (owners & tenants)
5.47	Precision makers, repairers, & smiths
5.51	Misc textile machine operators
5.54	Misc food prep workers
5.55	Extruding & forming machine operators
5.66	Painters, construction & maintenance
5.68	Elevator operators
5.73	Construction trades, n.e.c.
5.75	Construction laborers
6.11	Welders & metal cutters
6.15	Plasterers
6.18	Assemblers of electrical equipment
6.22	Laundry workers
6.32	Packers & packagers by hand
6.36	Mixing & blending machine operatives
6.40	Production helpers
6.72	Concrete & cement workers
6.91	Structural metal workers
7.12	Other woodworking machine operators
7.14	Punching & stamping press operatives
7.17	Aircraft mechanics
7.34	Mechanics & repairers, n.e.c.
7.34	Housekeep, maids, butlers, & lodging quarters cleaners
7.50	Slicing & cutting machine operators
7.67	Painting machine operators
7.88	Small engine repairers
7.99	Upholsterers
8.23	Janitors
8.30	Masons, tilers, & carpet installers
8.41	Dressmakers & seamstresses
8.48	Misc material moving occupations
8.95	Butchers & meat cutters
9.13	Textile sewing machine operators
9.78	Plant & system operators, stationary engineers
9.88	Washing, cleaning, & pickling machine operators
10.00	Grinding, abrading, buffing, & polishing workers
10.84	Industrial machinery repairers
11.43	Farm workers
11.77	Gardeners & groundskeepers
11.95	Hand molders & shapers, except jewelers
14.49	Graders & sorters of agricultural products
14.64	Drillers of earth
14.79	Typesetters & compositors
14.96	Laborers outside construction
16.02	Metal platers
16.32	Molders, & casting machine operators
16.93	Helpers, surveyors
18.47	Machine feeders & offbearers
19.18	Vehicle washers & equipment cleaners
19.67	Repairers of household appliances & power tools
19.77	Bookbinders
19.82	Other mining occupations
22.77	Miners
26.34	Excavating & loading machine operators
26.88	Shoemaking machine operators
36.89	Engravers
43.87	Fishers, hunters, & kindred
78.22	Paperhangers
93.43	Furniture & wood finishers
93.71	Pressing machine operators (clothing)
137.14	Operating engineers of construction equipment
146.72	Roofers & slaters
268.27	Drywall installers