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Contributions of Immigrant Farmworkers to California Vegetable Production

Stephen Devadoss and Jeff Luckstead

A major concern with immigrants coming into the United States is that they adversely affect domestic workers through job competition and wage depression. We study the displacement and wage reduction effects of immigrants in California vegetable production, which is labor intensive, and 95% of the farmworkers in California are immigrants. Our findings show that this concern is not valid in vegetable production because the addition of one new immigrant displaces only 0.0123 domestic workers, and wage reduction is inconsequential. But one immigrant worker increases the vegetable production by $23,457 and augments the productivity of skilled workers, material inputs, and capital by $11,729.

Key Words: employment displacement, immigrant labor, vegetable production, wage effect

JEL Classifications: J43, J61

According to the 2002 Census of Agriculture, about 554,000 U.S. farmers employed 3 million immigrant farmworkers and paid $18.6 billion in wages and salaries (National Agricultural Statistics Service [NASS]), which underscores the importance of these workers to U.S. farm production and a potential labor cost increase if these workers are not available. The National Agricultural Worker Survey (NAWS) documents that in 2001–2002, 78% of workers in U.S. farm production were immigrants, and 75% were from Mexico.[1] The same survey reports that 80% of the newly hired agricultural labor force is from Mexico, of which 96% are unauthorized (NAWS). These numbers are even higher for California because of its contiguous location to Mexico (Martin, 2007a).

The previously mentioned statistics indicate that without immigrant laborers, several critical farm tasks could not be completed. Numerous news media reports have elaborated the acute labor scarcity in many parts of the country. For example, the *Wall Street Journal* reports that, in 2006, about 20% of agricultural products were not harvested nationwide, and the losses in 2007 were estimated to be even higher, particularly in California. *Rural Migration News* provides a detailed and specific list of these shortages and how they adversely affected crucial cultivational operations, which resulted in heavy losses. A large number of acres of vegetable crops were not harvested, and fruits in numerous orchards went unpicked because of a labor shortage, particularly in the western

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[1] The NAWS data cover only workers employed in crop production, which comprises of most of the hired farmworkers.

states.[2] As a result, farm groups are one of the strongest allies of the current comprehensive immigration reform because if the number of undocumented workers dwindles, many growers will be affected and go out of business, particularly those growing labor-intensive fresh produce. Although several immigration bills were introduced and contentiously debated in the Congress, none were passed, including the "AgJob" provision that allows 1.5 million new guest workers, even though farm groups strongly supported this provision (see U.S. Department of Labor [2007] for various provisions of the AgJob bill). The major concerns are whether to grant illegal immigrant the legal status, which opponents have labeled amnesty and U.S. workers' apprehensions about losing their jobs to immigrants.

California has one of the largest agricultural labor markets in the country, accounting for 36% of farmworkers (Mason and Martin). The Migrant and Seasonal Enumeration Study by the Bureau of Primary Care's Migrant Health Program reports that 1.1 million seasonal farm laborers are working in California agriculture (Mines); of those, 440,000 are actually employed year-round; that is, only about 40% of farmworkers are employed throughout the year, or every full-time employment is filled by 2.5 workers (Martin, 2007b). Forty percent of these laborers work in the leading five agricultural counties in California: Fresno, Monterey, Kern, Tulare, and Ventura. Immigrants are the primary source of farm workforce for labor-intensive agriculture, such as fruit and vegetable production, in much of the western United States, particularly in California because of its close proximity to Mexico (Taylor). Since California has traditionally relied on immigrant laborers for farmwork, California agricultural workers are predominantly foreign born, with 95% of the labor employed born outside the country (Mason and Martin; Mines, Gabbard, and Steirmen). California also employs 26.5% of hired workers in U.S. vegetable and melon farms, which is more than double the employment of the second-ranked state, Florida (NASS).

Labor-saving technologies and fewer acres planted overall have not reduced the demand for low-skilled labor in California because farm trends have been shifting to labor-intensive crops. In particular, growth in vegetable crops, more than any other crops, has increased over the past 30 years because vegetable cultivation has also expanded to year-round, leading to a greater demand for low-skilled labor. The peak demand for seasonal labor in California is in July and August, whereas the off-season occurs in December, January, and February. Yet the difference in employment between the peak and off-season is only 1.6 times, implying that the need for farmworkers remains high even in the off-season (Mines). To maintain a steady and stable availability of farmworkers, California growers are also using labor contractors to supply a low-skilled farm workforce rather than hiring directly.

The purpose of this study is to assess the importance of immigrant labor for vegetable production in California. Specifically, we analyze the displacement and wage effects of immigrant farmworkers on U.S. and legal immigrant farmworkers and the complementary effects of these laborers on skilled farm labor (e.g., managers), material, and capital inputs.[3]

The results of this study will be useful for evaluating various immigration policy options, such as legalizing illegal immigrants and the guest-worker program. Hence, it is worth analyzing the effect of additional immigrant labor force in a labor-intensive agricultural production sector. California is chosen for this study because it ranks number one in the United States in vegetable production as

[2] For example, Gans estimates that a mere 15% reduction in the immigrant farm workforce can result in direct loss of $601 million to Arizona agricultural sector.

[3] Large-scale studies have examined the macroeconomic impacts of immigrants in a general equilibrium framework by taking into account the production activities (labor input, employment), fiscal costs (health care, education, law enforcement), fiscal gains (direct tax receipts), demand impacts (consumption purchases), and spillover effects (see Gans). While these studies investigate economy-wide impacts, the focus of this study is more at the microlevel on a specific group of commodities (vegetable) involving labor-intensive production in a state (California) where immigrant workers are the predominant farm workforce.

elaborated in the next section. In the third section, we present the theoretical analysis by first focusing on the interrelationship between low-skilled native and immigrant agricultural workers and then incorporating this relationship into vegetable production functions to examine how the immigrant workforce contributes to the productivity of other factors. The fourth section describes the data and parameters used in the analysis. The fifth section presents the empirical analysis and quantifies the effects of the immigrant workforce on various factors and production. The final section concludes by highlighting the policy implications of the findings for U.S. farm production and immigration reforms.

California Vegetable Market

Based on value of production, California agriculture is the largest in the country and the fifth-largest supplier of farm products in the world market (California Department of Food and Agriculture [CDFA] 2006a). About one-half of all vegetables,[4] fruits, and nuts produced in the United States are grown in this state (CDFA 2006b). The California Agricultural Resource Directory of the CDFA highlights the significance of California vegetable production in the United States, which is briefly summarized here. California is not only an important supplier of vegetables in the national market but also in the global market because of suitable climatic and soil conditions, access to highly developed technology, and availability of low-skilled immigrant farm workforce for the labor-intensive production systems. As a result, California leads the nation in vegetable yield per acre; of all the fresh vegetables grown in the nation, California produces 63% but uses only 46% of the area harvested nationally.

Between 2003 and 2005, vegetable production in California generated 20% of the total gross cash income in the state's agricultural industries and averages about $6.698 billion a year in value (CDFA 2006a). Of the top 20 agricultural products produced in California in 2005, four are vegetables: lettuce accounts for $1.69 billion, tomatoes (fresh and processed) for $942 million, broccoli for $514 million, and carrots for $455 million. The value of these four vegetables comprises 11% of the $32 billion in gross cash income from agricultural production (CDFA 2006a). According to the Economic Research Service, U.S. per capita consumption of processed vegetables increased by 2% and consumption of canned vegetables by 3% in 2005 (U.S. Department of Agriculture [USDA]). This higher demand for vegetables is partly met by the supply from California. Furthermore, vegetable production in California almost tripled in the past 30 years, increasing from 9 million tons to 25 million tons (Mines). During this period, California agriculture has been diverting acreage away from field crops and pastures to vegetables, fruits, nuts, and nursery products, and growth in vegetable production is the most significant.[5] In 2005, the largest increase in production came from cucumbers, fresh market spinach, pumpkins, and chili peppers, which improved by 15%, 15%, 14%, and 7%, respectively (CDFA 2006a).[6] California produces about 23 different vegetables; 11 of the 23 are grown year-round, and nine are in season for 6 months or more. As a result, a large percentage of the growers producing vegetables require low-skilled labor year-round. Furthermore, farmers are extending their growing seasons and increasing the frequency of planting, and consumers nationwide are increasing their demand for agricultural products, especially fresh vegetables, throughout the year, resulting in further demand for low-skilled farm labor.

Theoretical Analysis

The first part of this section covers the labor market interactions between immigrant and

[4] In all the discussions throughout the paper, vegetables refer to both vegetables and melons.

[5] For example, production of sweet corn increased by 4.14 times, broccoli by 3.51 times, lettuce by more than 2 times, processed tomato by almost 2 times, cauliflower by 1.65 times, cabbage by 1.44 times, fresh tomatoes by 1.14 times, and carrots by 1.05 times (Mines).

[6] In addition, California produces 99% of the national total in the following agricultural products: almonds, artichokes, clingstone peaches, dried plums, figs, olives, persimmons, pomegranates, raisins, Ladino clover seed, sweet rice, and walnuts.

domestic farmworkers.[7] The second part examines how these interactions impact other factors and vegetable production. The theoretical model employed in this study is a simple extension of the model developed by Johnson (1980), who examines the impact of immigrant workers in a macroeconomic context. We adapt his model to study the impact of immigrant farmworkers in a microeconomic context and apply it to a specific market, that is, the California vegetable market. We also expand on Johnson's interpretation of results to provide additional economic insights.

Labor Market Displacement

One of the concerns of immigrants coming into the United States is that they displace the domestic workers and depress wages.[8] Although this is a legitimate concern, the adverse economic effects depend on the labor market conditions and the occupation characteristics in a particular sector where the immigrants are seeking work as well as the employment conditions in other sectors and the overall macroeconomic environment in the country. Here we consider three possible cases of how the immigrants can impact the domestic workers in a particular sector.

Figure 1 depicts these three cases for low-skilled labor market, where S is the supply of domestic farmworkers, the difference between S and S' reflects the addition of immigrant farmworkers, and D is labor demand for both types of farmworkers. Case 1 depicts a labor market with a positively sloped supply curve and a negatively sloped demand curve. In this case, additional immigrant workforce will depress the wage rates and also displace domestic workers in this sector. But this displacement (ab in panel A) will be less than the number of immigrant workers added (ac in panel A) to this labor market. Case 2 involves a labor market where domestic labor supply is already in excess, unemployment exists, and wage rates are rigid for institutional and government policy reasons.[9,10] Labor supply in this case is perfectly elastic (up to the labor endowments) at the fixed real wage rate (panel B). Since unemployment already exists in this sector and if immigrants are absorbed, they will be displacing the domestic workers on a one-to-one basis. In panel B, the existing unemployment of domestic farmworkers is *de*, and if *fd* ($=S' - S$) number of immigrants are added to the labor market, unemployed native workers will increase to *fe*. Case 3 deals with a fixed amount of labor working in this sector; that is, labor supply is inelastic (panel C). In this case, an additional immigrant laborer will depress the wages but will not displace the domestic workers.

[7] Domestic or native farmworkers refer to U.S. citizens and legal residents. In the empirical analysis, we examine how the immigrants impact not only domestic workers but also existing immigrants.

[8] Considerable controversy exists among the economists regarding the employment displacement and wage effects of immigrants. For example, Borjas, Friedman, and Katz found that if wages are compared in labor groups stratified on the basis of education–work and experience–years, the groups with relatively high inflow of immigration also have relatively slow wage growth. However, Bohn and Sanders reported that if a few data points are removed, Borjas, Friedman, and Katz's findings are easily changed. Furthermore, they elaborate that it is important to control for changes in technology, increasing trade with developing countries, and decreases in the real minimum wage in examining wage effects of immigration. Additionally, Raphael and Ronconi documented that high rates of imprisonment for American high school dropouts negatively affect wage rates in the experience–education group and if that is controlled, the immigration effects on wages are reduced. Friedberg and Hunt also reported that the effects of immigrants on low-skilled native workers are very small; that is, a 10% rise in immigrants reduces the low-skilled wages by only 1% and has no effect on unemployment during the economic expansion. This finding is also corroborated by Butcher and Card, Card (1990, 2001), Friedberg, and Lewis. Ottaviano and Peri found that if natives are scarce in certain occupations and immigrants are relatively abundant, then immigrants could complement U.S. workers in that sector. Accounting for this complementarity, they estimated that for the period 1980–2000, the immigrant workforce boosted the average wage of U.S.-born workers by about 2%.

[9] An example of government policies that can result in wage rigidity is minimum-wage legislation, though it can allow for upward flexibility in a tight labor market.

[10] Labor demand is negatively sloped in all three cases because perfectly elastic and inelastic labor demand functions do not make economic sense.

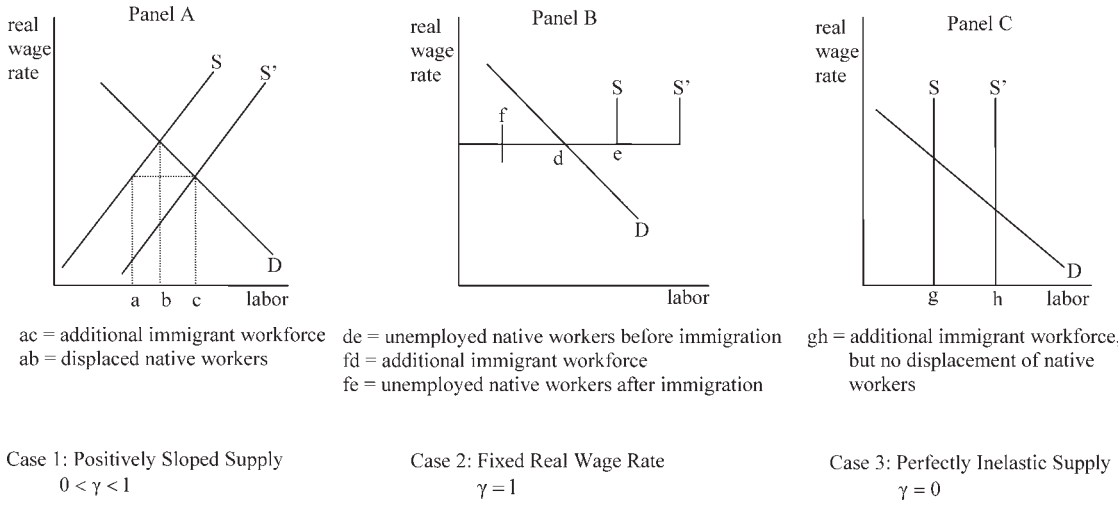

Figure 1. Low-Skilled Labor Market

Next we mathematically show the effects of an exogenous change in immigrant labor supply on domestic workers' employment and wage rates for these three cases. Consider the domestic labor supply function

$$L_{UD} = S(w_U),$$

where L_{UD} is low-skilled domestic workers and w_U is the real wage rate. The total low-skilled labor supply (L_U) in this sector is the sum of domestic and immigrant low-skilled workers (L_{UI}):

$$L_U = L_{UD} + L_{UI}.$$

The total demand for low-skilled laborers in this sector is given by

$$L_U = D(w_U).$$

The labor market equilibrium is

$$L_{UD} + L_{UI} = D(w_U).$$

Totally differentiating this equilibrium condition and expressing it in proportional change, we can examine the effects of an exogenous addition of an immigrant worker on the wage rate:

$$d\log w_U = \frac{-1}{\eta_U + \varepsilon_U(1-\theta)}\frac{dL_{UI}}{L_U},$$

where $\eta_U = -[(d \log L_U)/(d \log w)]$ is the absolute elasticity of labor demand, $\varepsilon_U = [(d \log L_{UD})/(d \log w_U)]$ is the elasticity of domestic labor supply, and $\theta = L_{UI}/L_U$ is the share of low-skilled immigrant workers in this sector. This equation entails that the decline in the wage rate depends on labor supply and demand elasticities and the share of the immigrant workforce. As explained previously for case 1 (positively sloped supply) and case 3 (inelastic supply), addition of immigrants workers reduces the wage rate. For case 2 (fixed wage, $\varepsilon_U \to \infty$), the wage rate does not decline. If a large number of immigrants come into this sector, *ceteris paribus*, the wage decline will be larger, as revealed by the previous equation.

To analyze the employment displacement effect of immigrants on domestic workers, totally differentiate the domestic labor supply function and substitute the previously mentioned wage impacts to obtain

$$(1)\ dL_{UD} = -\frac{\varepsilon_U(1-\theta)}{\eta_U + \varepsilon_U(1-\theta)}dL_{UI} = -\gamma dL_{UI},$$

where $[\varepsilon_U(1-\theta)]/[\eta_U + \varepsilon\,(1-\theta)] = \gamma$ is the displacement coefficient, which ranges from 0 to 1. When labor supply is positively sloped, γ is a fraction, and case 1 prevails; when unemployment exists and the real wage is rigid, γ is 1, and case 2 prevails; and when domestic labor supply is perfectly inelastic, γ is 0, and case 3 prevails. One important point to note is that, *ceteris paribus*, the smaller the share of domestic low-skilled labor force (1 −

θ) in this sector, the smaller the displacement effect of immigrants. Using the definition of γ, the wage-effect equation can be rewritten as

$$(2) \qquad d\log w_U = -\frac{(1-\gamma)}{\eta_U}\frac{dL_{UI}}{L_U}.$$

For the same addition of new immigrant workers, the wage rates will decline more under case 3 ($\gamma = 0$), less under case 1 (γ is a fraction) and will not change under case 2 ($\gamma = 1$).

Distributional Effects of Immigrants Farm Labor

Next, we utilize the low-skilled labor market relations developed previously to analyze how the immigrant workforce augments the productivity of other factors. Consider the linear homogeneous and constant elasticity of substitution (CES) production function $y = F(L_U, L_S, M, K)$, where y is vegetable output, L_U is unskilled labor, L_S is skilled labor, M is material input, and K is capital. In this study we consider the skilled workers to be comprised of managers and supervisors, owner/farmers, and hired consultants. First, we derive the impact of low-skilled workers on factor prices of skilled labor, materials, and capital. From the profit maximization, the first-order conditions are

$$\begin{aligned} w_U &= F_U(L_U,L_S,M,K),\\ w_S &= F_S(L_U,L_S,M,K),\\ v &= F_M(L_U,L_S,M,K),\\ r &= F_K(L_U,L_S,M,K), \end{aligned}$$

where w_U is real wage rates of unskilled labor, w_S is real wage rates of skilled labor, v is real price of materials, and r is real rental rate of capital. Differentiating the second first-order condition by keeping L_S, M, and K constant (i.e., these factors are fixed in the short run), we obtain

$$dw_S = F_{SU}dL_U.$$

For linear homogeneous and CES production function, the previous equation can be transformed to yield

$$(3) \qquad d(\log w_S) = \frac{\alpha_U}{(1-\alpha_U)\eta_U}d(\log L_U),$$

where α_U is the share of low-skilled labor earnings of total output. We can derive similar expressions for changes in v and r using the third and fourth first-order conditions, respectively. Thus,

$$(3') \qquad \begin{aligned} d(\log w_S) &= d(\log v) = d(\log r)\\ &= \frac{\alpha_U}{(1-\alpha_U)\eta_U}d(\log L_U). \end{aligned}$$

These results show that the immigrant workforce augments the productivity of skilled workers, material input, and capital. Next, consider the distributional effect resulting from the employment of immigrant workers. For linear homogeneous production function, as per Euler's theorem, output is distributed to all the inputs as

$$y = w_U L_{UI} + w_U L_{UD} + w_S L_S + vM + rK.$$

Totally differentiating this equation and using Equations (1) to (3′), we ascertain the contribution of a new immigrant employed in production:

$$\begin{aligned} \frac{dy}{dL_{UI}} &= w_U \text{ (new immigrant farmworkers' earnings)}\\ &\quad -\left[\gamma + \frac{(1-\gamma)}{\eta_U}(1-\theta)\right]w_U \text{ (native farmworkers' earnings)}\\ &\quad -\frac{(1-\gamma)}{\eta_U}\theta w_U \text{ (existing immigrant farmworkers' earnings)}\\ &\quad +\frac{\alpha_S}{(1-\alpha_U)\eta_U}(1-\gamma)w_U \text{ (skilled farmworkers' earnings)}\\ &\quad +\frac{\alpha_M}{(1-\alpha_U)\eta_U}(1-\gamma)w_U \text{ (materials' earnings)}\\ &\quad +\frac{1-\alpha_U-\alpha_S-\alpha_M}{(1-\alpha_U)\eta_U}(1-\gamma)w_U \text{ (capital's earnings)} \end{aligned} \qquad (4)$$

This result captures the decomposition of output to each factor group's contribution arising from one additional immigrant fieldworker, and the interpretation of each component is as follows. Observe that since γ explicitly appears in Equation (4), the distributional effects on total output can be analyzed for all three cases of labor market conditions. However, we focus primarily on the normal case of positively sloped labor supply and negatively sloped labor demand, that is, case 1 (γ is a fraction). One additional immigrant laborer increases the output by his or her earnings (i.e., the real wage rate). But because this additional immigrant laborer displaces the unskilled farmworker (both native and existing immigrant workers) and reduces the wage rate, the contribution of the unskilled workers to output declines. The adverse effect on native worker is given by the term $-\{\gamma + [(1 - \gamma)/\eta_U](1 - \theta)\}w_U$. Specifically, the displacement effect is $-\gamma w_U$ (i.e., the displacement coefficient [see Equation (1)] times the wage rate), and the wage effect is $-\{[(1 - \gamma)/\eta_U](1 - \theta)\}w_U$ (i.e., the wage reduction coefficient [see Equation (2)] times the share of domestic workforce times the wage rate). The addition of a new immigrant laborer can also adversely affect the earnings of existing immigrant workers. For example, Card (2001) and Ottaviano and Peri provide empirical evidence that new immigrants lower the wages of existing immigrants. In our model, the existing immigrants' contribution to the total output will decline by $[-(1 - \gamma)/\eta_U]\theta w_U$ (i.e., the wage reduction coefficient times the share of immigrant workforce times the wage rate). The effect on all unskilled labor is the sum of the terms corresponding to domestic and immigrant workers, which is equal to $-[\gamma + (1 - \gamma)/\eta_U]w_U$.

Since an additional immigrant laborer enhances the productivity of skilled workers, material input, and capital, all these inputs augment the output. Each of these input's contribution equals to wage increase effect (see Equation [3′]) times its productivity parameter (α) times the net contribution of new immigrant to output $(1 - \gamma)w_U$, which is explained next.[11] This result corroborates the findings of Ottaviano and Peri, who report that the immigrant workers have a positive impact on the wages of native skilled workers with at least a high school diploma. In addition, immigrant fieldworkers have an important redistributive effect; that is, they may reduce the earnings of existing fieldworkers but boost the earnings of other factors of production. This transfer from all three groups of fieldworkers (new immigrant, domestic, and existing immigrant fieldworkers) to the other three factors of production is equal to $[(1 - \gamma)/\eta_U]w_U$, which can be obtained by summing the earnings of skilled workers, materials, and capital or summing the earnings of three groups of fieldworkers and subtracting it from output increase.

The right-hand terms in Equation (4) can be summed to obtain

$$\frac{dy}{dL_{UI}} = (1 - \gamma)w_U = w_U - \gamma w_U$$

(net contribution of new immigrant to output).

Thus, the output increase due to an additional immigrant is his or her contribution (w_U) minus the loss of earnings of the displaced low-skilled worker (γw_U). Hence, the displacement coefficient plays a critical role in determining the contribution of immigrant fieldworkers. The smaller this coefficient, the fewer the displaced domestic fieldworkers and the larger the output increase and the contribution of skilled workers, material input, and capital.

Data and Parameters

To empirically implement the theoretical model, we need the following information: 1) the elasticity of demand for farmworkers (η_U), 2) the elasticity of supply of farmworkers (ε_U),

[11] The net contribution $[(1 - \gamma)w_U]$ as opposed to gross contribution (w_U) of the new immigrant worker enters into these three factors' productivity components because of the indirect effects of immigrants through these factors rather than a direct effect through the low-skilled workers.

3) the ratio of immigrant farmworkers to total farmworkers in California vegetable production (θ), 4) wage earnings, 5) cost share parameters (αs), and 6) the total value of California vegetable production. Since the theoretical model uses linear homogeneous function, as per Euler's theorem, total value of production is equal to the sum of the payments to each factor of production. Consequently, the sum of the αs is equal to 1. Next we describe in detail the data collection, parameter construction, and their sources.

Elasticity Parameterization

Since time-series data for various cost measures and vegetable production in California do not exist, demand and supply elasticity values for hired farm labor were obtained from the existing literature. Espey and Thilmany conducted an extensive review of literature and reported farm labor demand elasticities from 29 studies, and these elasticities ranged from 0.22 to -4.42.[12] This wide range of elasticities is attributed to differences in time periods (some studies covered the early 1900s, and more recent studies covered late 1900s), theoretical models, empirical specifications, estimation methods, and studies from several countries. More important, these demand elasticity estimates covered hired, family, or aggregate farm labor. Since we need only the elasticities of hired farm labor for the current study, we focused our elasticity search only on those studies that dealt with hired farm labor, which are presented in Table 1.

Earlier studies (Heady and Tweeten; Martinos; Schuh; Tyrchniewicz and Schuh) found hired labor demand elasticity to be inelastic in both the short and the long run, ranging from -0.12 to -0.60. However, Hammonds, Yadav, and Vathana concluded that since the 1930s the demand elasticity for hired labor consistently increased overtime and predicted that it will become more elastic, which has also been confirmed by the other studies, most notably by Duffield. In particular, studies that were conducted after 1990 (Duffield; Duffield and Coltrane; Fernandez-Cornejo; Napasintuwong and Emerson) found hired labor demand to be elastic in the short run, ranging from -1.38 to -2.08. The latter studies also estimated long-run demand elasticity to be very elastic, ranging from -3.14 to -11.45. The increasing trend in labor demand elasticity can be attributed to off-farm work availability to laborers. Napasintuwong and Emerson, in their study on labor substitutability in labor-intensive agriculture that includes perishable crops, estimated elasticity of hired labor demand ranging between -1.89 and -2.04.

These elasticity values are more likely to be representative of the labor demand elasticities in California vegetable production. Since all the latter studies report elastic hired farm labor demand elasticity, we consider an elasticity of -2.0 for benchmark analysis and two alternate values of -1.0 and -5.0 for sensitivity analyses.

A few studies report hired labor supply elasticity in agricultural production and find labor supply to be inelastic in the short run. Long-run labor supply elasticity is also generally inelastic, except in two studies (Tyrchniewicz and Schuh; Wang and Heady). Furthermore, unlike in the case of demand elasticity, supply elasticity does not exhibit an increasing trend. Taylor and Thilmany note that labor supply elasticity of farmworkers is not high in the western United States. Based on this study, the hired labor supply elasticity value of 0.5 is utilized for the benchmark analysis and two alternate values of 0.1 and 0.75 for sensitivity analysis. We expect the benchmark elasticity values to yield the most plausible employment displacement and wage impacts and sensitivity analyses to provide lower and upper bounds of the impacts of immigrant workforce.

[12] Espey and Thilmany observe that the positive labor demand elasticity in some studies are attributed to extremely short harvest periods or record yields, which can lead to wage increase and more labor employment. Consequently, they omitted the positive labor demand elasticity values and considered only the negative values in their analysis.

Table 1. Hired Labor Demand and Supply Elasticities

Studies	Short-Run Elasticities	Long-Run Elasticities
Demand		
Schuh	−0.12	−0.40
Heady and Tweeten[a]	−0.26 and −0.48	−0.37 and −0.60
Tyrchniewicz and Schuh	−0.26	−0.49
Martinos	−0.55	N/A
Hammonds, Yadav, and Vathana[b]	−0.85 and −2.23	−1.05 and −4.42
Binswanger	−0.91	N/A
Wang and Heady	−1.25	N/A
Brown and Christensen	−0.65	N/A
Ray	−0.84	N/A
Weaver	−1.02	N/A
Duffield	−1.44	N/A
Duffield and Coltrane	−1.38	−3.14
Fernandez-Cornejo[c]	−2.04 and −2.08	−11.45
Napasintuwong and Emerson[d]	−1.89 to −2.04	N/A
Supply		
Johnson (1961)	0.13	0.71
Schuh	0.25	0.78
Tyrchniewicz and Schuh	0.65	1.55
Hammonds, Yadav, and Vathana	0.24	0.82
Wang and Heady	0.17	1.34
Duffield	0.35	0.73
Duffield and Coltrane	0.36	0.76

[a] Heady and Tweeten considered two different periods (1929–1957 and 1940–1957) and reported short-run elasticities of −0.26 for the first period and −0.48 for the second period and long-run elasticities of −0.37 and −0.60 for these two different periods.

[b] Hammonds, Yadav, and Vathana report short-run (long-run) demand elasticities of −0.85 (−1.05) for the national labor market and −2.23 (−4.42) for the Oregon labor market.

[c] Fernandez-Cornejo estimated Hicksian elasticity of demand at −2.04 and Marshallian elasticity of demand at −2.08.

[d] Napasintuwong and Emerson's elasticity range is due to different periods from 1960 to 1998.

Vegetable Market Data

Boucher and Taylor observe that in 1996, 90% of California's agricultural workforce was foreign born, and Mines reports that 93.5% of California agricultural workers are from Mexico. But illegal immigration has expanded significantly in the past 10 years, as has the foreign-born agricultural workforce in California. For instance, Mason and Martin report that current foreign-born laborers in California agriculture are at 95%. Based on this information, we consider that the share of immigrant workforce in California vegetable production is also 0.95. The total number of full-time employees in California vegetable production is 65,871, and the number of immigrant workers in this sector is 62,577 ($0.95 \times 65{,}871$).[13] Martin (2007a) and Mason and Martin also report hourly wage rate for farmworkers in California at $9.50 in 2004, and a full-time employee working 2,500 hours per year can earn $23,750.

Data for California vegetable production costs were collected from a cost-and-return studies' database maintained by Rich DeMoura in the Department of Agricultural and Resource Economics at the University of California, Davis. For selected and recent

[13] Because of the seasonality nature and off-farm employment, each job is filled by 2.5 workers. Thus, the total number of workers is 164,677 = (65,871 × 2.5). This information was obtained from www.labormarketinfo.edd.ca.gov/cgi/databrowsing/?PageID=4&SubID=158 and personal communication with Philip Martin.

years, this database provides elaborate documentation of various cost categories and revenue information on a per acre basis of vegetable production for representative farms. These data are compiled on the basis of typical production practices for various vegetables. For this study, we included all the vegetables that were covered by DeMoura's cost-and-return studies.[14] For each vegetable, per acre cost data of various inputs and cultivational practices are grouped into four categories: low-skilled labor (fieldworkers), skilled labor (managers and supervisor, farmer-owners, consultants for pest and disease management), material, and capital costs. DeMoura and his colleagues' extensive write-up describing various input use, farm operations, and per unit costs for each vegetables production was used to compile the cost for these four input categories. Since skilled labor comprises of farmer-owners, payments to this group of workers include not only the specific cost incurred but also returns above the total cost as documented by Tourte et al.

Since the previously mentioned cost data are on a per acre basis, to obtain the total cost of producing vegetables in California, total acreage for each vegetable in the state is multiplied by its cost per acre. The vegetable acreage data came from NASS of the USDA. We considered the year 2004 for our study, but cost-of-production data for some vegetables was available only for earlier years. The cost of production for these vegetables was extrapolated using the priced paid data available at NASS.

The California Agricultural Resource Directory of the CDFA reports that the total revenue for all vegetables produced in California is $6.7 billion. Farm labor cost is about 28% of total revenues, which is consistent with the U.S. Department of Labor (2005) estimate that labor cost is about 30% of the total cost of vegetable production. Gunter, Jarrett, and Duffield used a labor-cost share of 29% at the national level for vegetable production, and they observe that this parameter is an important determinant of the impact of labor supply on production. The skilled labor share of cost of production is 20%, material input share is 35%, and capital input is 17%.

Empirical Analysis

The labor market in vegetable production differs from that of grain and livestock production because of differences in labor intensity, location, and number of migrants as well as the proportion of undocumented workers employed (Rosenberg). High labor-cost shares and heavy reliance on undocumented workers are characteristics of vegetable production, which was also observed by Gunter, Jarrett, and Duffield. These factors also play important roles in our empirical results.

First, we examine how an addition of 100 immigrant farmworkers affects the employment and wages of domestic farmworkers (Table 2).[15] These results depend on the share of immigrant workforce of total low-skilled workers (θ) and labor supply and demand elasticities (ε and η). For reasonable labor supply and demand elasticities (i.e., benchmark $\varepsilon = 0.5$ and $\eta = 2$), the addition of 100 immigrants will reduce the employment of domestic workers very minimally, by only 1.23. Even for the worst-case scenario ($\varepsilon = 0.75$ and $\eta = 1$), the displacement effect is only about 3.61. This displacement is certainly much smaller than a 1:1 reduction that many domestic workers and lawmakers dread. This result has profound policy implications because 1) the claim that immigrants are taking jobs away from native workers is not a valid argument, particularly in California vegetable production, since a) only a small (5%) percentage of domestic workers are employed in this sector and b) in contrast, the recent

[14] The vegetables included in the study are artichokes, asparagus, beans, bittermelon, broccoli, cabbage, carrots, cauliflower, corn, cucurbits, daikon, eggplant, lemongrass, lettuce, melons, onions, squash, sugar beets, sweet potatoes, and tomatoes. Broccoli and lettuce are grown as organic and nonorganic vegetables.

[15] Use of 100 immigrant workers allows the displacement and wage results to be presented in percent changes.

Table 2. Effect of 100 Additional Immigrant Workers on Domestic Fieldworkers and Wage Rates

	Displacement Effect			Wage Effect		
Elasticities	$\varepsilon_U = 0.1$	$\varepsilon_U = 0.5$	$\varepsilon_U = 0.75$	$\varepsilon_U = 0.1$	$\varepsilon_U = 0.5$	$\varepsilon_U = 0.75$
$\eta_U = 1$	−0.50	−2.44	−3.61	−0.0006	−0.00059	−0.00058
$\eta_U = 2$	−0.25	−1.23	−1.84	−0.0003	−0.0003	−0.0003
$\eta_U = 5$	−0.10	−0.50	−0.74	−0.0001	−0.0001	−0.0001

employment history in this sector reveals that the immigrant workers are doing the heavy manual and back-breaking work that most Americans are unwilling to do, and 2) given that the number of native workers employed in California agriculture is so small, should the policymakers be concerned about native workers losing their jobs or about California growers being unable to perform the critical operations, such as harvesting their crops, and incurring heavy losses? California congressional delegates in general are concerned about the loss to agricultural businesses and are in favor of 1) legalizing the illegal immigrants and 2) implementing a guest-worker program that will bring in foreign workers for a fixed period of farm employment.

The wage declines for benchmark elasticities are 0.0003% and even for the worst-case scenario are only 0.0006%. Again, these effects are almost nil because few domestic workers are employed in California vegetable production, and the argument that immigrant workers depress wages does not apply to this sector. Our findings also corroborate the results of several studies that found that the effects of immigrants on low-skilled domestic workers are very small in many different sectors.[16] Furthermore, if native workers can find jobs in other sectors of the economy, the wage decline due to immigrant workers coming into California vegetable production should not be of major concern for policymakers.

Next, we estimate the distributional effects of an additional immigrant fieldworker (Table 3). We consider the displacement coefficient of 0.0123 resulting from the benchmark elasticity values in Table 2. In addition to this, we also conduct sensitivity analyses for a displacement coefficient value of 0 (i.e., fully adjusting labor market without any job loss to native farmworkers) and 0.2 (immigrants induce 20% unemployment to native farmworkers, albeit an extreme assumption for the California vegetable sector). These lower and upper limits for the displacement coefficient (γ) cover all the range of values obtained in Table 2. We utilize the same labor demand and supply elasticities range as in Table 2; however, note that labor supply elasticity is embedded in γ and does not explicitly appear in Table 3.

Martin (2007a) reports that a full-time farm laborer works about 2,500 hours per year[17] and earns an average hourly wage rate of $9.50 per hour and $23,750 per year. These earnings or labor payments are the contribution of an addition of one immigrant full-time farmworker. For benchmark γ, the increase in the value of vegetable production, after accounting for displacement of domestic workers, is $23,457. Since 65,871 workers are employed in vegetable production, total direct value of production attributable to these workers is $1.55 billion. Gans estimated that immigrant farmworkers' direct production effect on vegetable production in Arizona (which is a much smaller producer than California) is $0.547 billion.[18] Sills, Alwang,

[16] For example, see Bohn and Sanders; Butcher and Card; Card (1990, 2001); Friedberg; Friedberg and Hunt; Lewis; Ottaviano and Peri; and Raphael and Ronconi.

[17] A seasonal labor works only 1,000 hours, which is equivalent to 2,500 hours of full-time employment.

[18] Gans reports that the cumulative effect, including all multiplier effects, of immigrant workers in Arizona's vegetable and melon production is $11.764 billion.

Table 3. Distributional Effect of One Additional Immigrant on Other Factors and Vegetable and Melon Production

	$\gamma = 0$			$\gamma = 0.0123$			$\gamma = 0.2$		
New immigrant	23,750			23,750			23,750		
Vegetable and melon production	23,750			23,457			19,000		
	$\eta_U = 1$	$\eta_U = 2$	$\eta_U = 5$	$\eta_U = 1$	$\eta_U = 2$	$\eta_U = 5$	$\eta_U = 1$	$\eta_U = 2$	$\eta_U = 5$
Total fieldworkers	−23,750	−11,875	−4,750	−23,750	−12,021	−4,984	−23,750	−14,250	−8,550
Native workers	−1,187	−594	−238	−1,465	−879	−527	−5,700	−5,255	−4,940
Existing immigrants	−22,563	−11,281	−4,513	−22,285	−11,142	−4,457	−18,050	−9,025	−3,610
Other factors									
Skilled workers	6,597	3,299	1,319	6,516	3,258	1,303	5,278	2,639	1,056
Material inputs	11,545	5,773	2,309	11,403	5,702	2,281	9,236	4,618	1,847
Capital	5,608	2,804	1,122	5,539	2,769	1,108	4,486	2,243	897

and Driscoll use an input–output model to study the economic impacts of migrant workers on agricultural production in Virginia.

Because of the employment of a new immigrant, the income loss to a domestic farmworker is only $879, which, as the displacement and wage-decline results given in Table 2, is also small and highlights the fact that domestic workers are only marginally impacted by the immigrant laborers. The loss to the existing immigrant worker is $11,142, and to both types of incumbent fieldworkers' earnings it is $12,021.

As the theoretical analysis showed, the other three factors of production benefit from the employment of a new immigrant. The skilled workers gain by $3,258. The rationale for this result is that if U.S. farm laborers are particularly scarce for performing hard, manual operations such as pesticide spraying and vegetable harvesting, immigrants are willing to perform these tasks, while U.S. workers can operate tractors, harvesters, and computers. Thus, foreign-born workers, by performing labor-intensive manual work, can complement U.S. workers in the agricultural operations. For example, Ottaviano and Peri found that in the manufacturing sector, if natives are sparse in certain occupations and immigrants are relatively abundant, then immigrants could complement U.S. workers in that sector. The new immigrant also boosts the productivity of material and capital inputs in the production process because the availability of these laborers allows the producers to expand the production by 1) increasing the acreage for more profitable vegetable cash crops and 2) growing several crops in a year and thereby utilizing these factors to their maximum potential. Consequently, material input earnings increase by $5,702, and capital remunerations rise by $2,769. The total earnings of these three factors increase by $11,729, implying that the benefit to these factors increases as more immigrant workers are available for vegetable cultivation. This result underscores the reason for the owners of these three factors (i.e., farmers and agricultural business) to support legalizing undocumented workers

and also implementing a guest-worker program for agriculture.

Sensitivity analyses for alternate values of labor demand elasticity show that the adverse effect of the new immigrant field laborer on both domestic workers and existing immigrant workers is further mitigated for more elastic labor demand because these incumbent workers respond more even for a small wage decline and will tend to seek employment in other sectors, such as construction and retail. If labor demand is less elastic, then the adverse impact is stronger, as the incumbent workers have fewer options in their employment opportunities. In contrast, the other three factors of production tend to benefit more under inelastic farm labor demand as greater transfers accrue from the fieldworkers to these factors because, under inelastic demand, enough laborers are available for farm operation even when wages decline. The converse results hold when labor demand is more elastic.

Comparison of the results for alternate values of displacement coefficient reveals that, as one would expect, the higher the γ (i.e., more domestic workers lose their jobs), the larger the decline in domestic workers' earnings and the smaller the increase in skilled workers', material's, and capital's earnings. Consequently, the value of vegetable production also increases less if the displacement rate is higher. However, existing immigrants' earnings decrease less because these workers face only the wage-reduction effect but not the displacement effect (see the interpretation of Equation [4]). The largest output increase and smallest distributions between fieldworkers and other factors occur under zero employment displacement and more elastic factor demand. In contrast, the smallest output increase and larger transfers occur if the displacement effect is larger and labor demand is less elastic.

Conclusions and Implications

Immigration has become an important issue in the United States because 12 million illegal immigrants are currently residing in the country and foreigners are constantly entering the country unlawfully. Even though there is widespread agreement among the public and elected officials that immigration reforms need to be resolved, no consensus has emerged on how to overhaul immigration laws. One of the major sticking points is whether to grant current illegal immigrants legal status, which opponents have labeled as amnesty to lawbreakers. Another concern is that U.S. low-skilled workers may lose their jobs to immigrants. In contrast, growers, who are in dire need of workers, support legislations that legalize these immigrants. Although the immigration reform was hotly debated in the U.S. Congress and dragged on acrimoniously over a 2-year period, several problematic issues were not resolved, and the lawmakers eventually failed to enact any immigration legislation.

Immigrants have helped to expand labor-intensive agricultural commodities and to control production costs in recent years by providing the necessary supply of labor. Particularly in California, the large number of immigrant farm laborers working in the farm sector has notably enhanced the state's share of agricultural production in U.S. and global markets. Since 95% of the farmworkers in California are immigrants and 57% of them are undocumented workers (Mason and Martin), reduction of this unauthorized workforce will have detrimental consequences for California agriculture in general and vegetable production in particular. Since domestic farmworkers make up only 5% of the workforce, job loss due to employment of immigrant workers does not pose a problem; rather, the dire need of immigrant workers to complete several of the critical farm operations is a serious problem. Our results show that 100 new immigrant workers displace domestic farmworkers by only 1.23 and thus reduce wages only inconsequentially. But the positive contributions of immigrant workers far outweigh these smaller losses as the earnings of other factors and vegetable production rise significantly. Furthermore, will reducing the immigrant farm workforce get the domestic workers to take hard labor jobs on the farms?

Given that only 5% of the farm jobs are performed by domestic workers, it is unlikely that farmers will be able to find domestic workers even at higher wages, as is evident from the labor shortages in the past 2 years.

Most of the field jobs in California vegetable production are performed by undocumented workers. Growers who heavily rely on undocumented workers are facing labor shortages because of border crackdowns and workplace raids (Johnson 2007). Any reduction of the immigrant workforce, by deporting undocumented workers and scuttling the guest-worker program, will have several adverse implications to U.S. agriculture. Producers in several states, particularly in the western states, have been beset with labor scarcity and are experiencing devastating effects on farm production and profitability, particularly in labor-intensive crops, because farmers could not complete many of the basic tasks, such as planting and harvesting. Government policies aimed at deporting unauthorized workers will adversely affect the supply of seasonal and nonseasonal labor to crop production. As a result, many crops will go unharvested and can cause numerous farmers to go out of business. Consequently, consumers will incur higher costs for fruits and vegetables at the grocery stores, as has been the case in the past 2 years. The results of this study support legislation for a guest-worker program, which was also strongly advocated by farmers, to provide the needed farm laborers.

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