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California's Wage Rate Policies and Head Lettuce Prices

Lynn Hamilton,[a] Michael P. McCullough,[b] Gary W. Brester,[c] and Joseph Atwood[d]

[a]*Professor, Agribusiness Department,*
California Polytechnic State University, 1 Grand Avenue
San Luis Obispo, California 93401 USA

[b]*Professor, Agribusiness Department,*
California Polytechnic State University, 1 Grand Avenue,
San Luis Obispo, California 93401 USA

[c]*Professor Emeritus, Department of Agricultural Economics and Economics,*
Montana State University, PO Box 172920,
Bozeman, Montana 59717-2920 USA

[d]*Professor, Department of Agricultural Economics and Economics,*
Montana State University, PO Box 172920,
Bozeman, Montana 59717-2920 USA

Abstract

We develop an *ex ante* analysis of labor wage regulatory impacts on the head lettuce industry to estimate the impact of future California wage rate increases. We construct an equilibrium displacement model based on 2006 and 2017 head lettuce case studies to estimate the direction and size of changes in head lettuce quantity and prices given presumed changes in labor costs based on California's legislated wage rate increases. We find that a 20% increase in the wage rate for California agricultural labor will increase the retail price of head lettuce by 7.7% and reduce the quantity demanded of head lettuce by 4.3%.

Keywords: equilibrium displacement model, farm labor wages, lettuce, regulations

Corresponding author: Tel: (406) 994-7883
Email: gbrester@montana.edu

Introduction

Lettuce represents the sixth largest crop (in terms of total revenue) produced in California, with a 2017 farmgate value of $2.41 billion and 199,100 harvested acres. Head lettuce represents 42% of that production, with 83,500 acres and a farmgate value of nearly $1 billion. Head lettuce production is highly seasonal because of the need for warm (but not hot) days and cool nights. Hence, monthly head lettuce regional harvests (primarily between California and Arizona) only marginally overlap (Figure 1). Moreover, California produces 64% of all head lettuce shipped in the United States, with most production occurring between April and October. In addition, head lettuce is a highly labor-intensive crop, especially during the harvesting process.

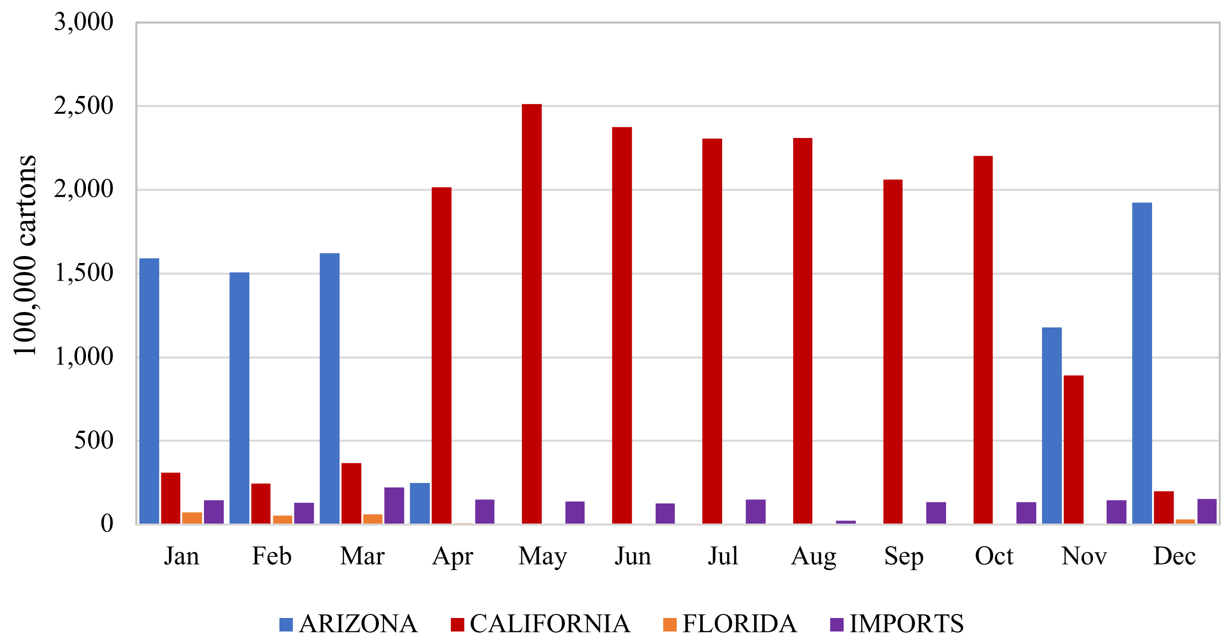

Figure 1. Iceberg Lettuce Shipments by Origins and Months

Over the past two decades, a variety of factors have limited the supply of agricultural labor in the United States (Kostandini, Mykerezi, and Escalante, 2014; Fan et al., 2015; Charlton and Taylor; 2016; Richards, 2018). In addition, increased regulatory policies with respect to human resources in California production agriculture have increased labor costs. New California wage and overtime regulations related to agricultural labor will further increase labor expenses, which may ultimately reduce the acreage of labor-intensive crops such as head lettuce. This will increase head lettuce prices and reduce the quantity demanded of head lettuce, further reducing the likelihood of meeting various governmental recommendations regarding increased consumption of vegetables. U.S. consumers currently consume fewer vegetables than recommended in the U.S. Department of Agriculture's's *Dietary Guidelines* (Wells and Buzby, 2008; Center for Science in the Public Interest, 2015).

We document the likely increases in labor costs as the result of new wage requirements in California using case studies and the regulatory policies that are currently being implemented. We then use an equilibrium displacement model to evaluate the impact of increased labor wages on head lettuce prices and consumption.

California Agricultural Wage Policies

The California regulatory environment is constantly evolving in response to new laws, policies, and legislative mandates. Regulations can provide benefits to the agricultural industry and society at large by improving food safety, air and water quality, and working conditions for farm workers. However, regulations also impose compliance costs on agricultural businesses. Regulatory costs can be classified as either direct, involving a cash outlay in response to the regulation, or indirect, involving an opportunity cost to the business or industry as a result of the regulation.

Both federal and state laws have dramatically increased labor costs for California producers. The Affordable Care Act (ACA) of 2010, which went into effect in 2014, requires all employers with 50 or more full-time or full-time-equivalent employees to provide health care coverage for their workforce and file requisite paperwork regarding that coverage to both the U.S. Internal Revenue Service and employees. This regulation likely affects the largest lettuce production firms, which represent over 67% of California's head lettuce production (Table 1). Other regulations, however, are not dependent on firm size. Human heat stress and illness prevention measures were adopted by the California Occupational Safety and Health Administration (Cal OSHA) in 2006 for those in outdoor occupations, including agriculture. In 2015, the standards were strengthened and required employers to provide shade structures that provide coverage for all employees when air temperatures exceed 80ºF. In addition, employers must provide clean, cool drinking water and preshift heat stress training to remind workers to drink sufficient water and take work breaks. Farming operations are subject to unannounced compliance inspections by Cal OSHA, with fines assessed for any violations.

Table 1. 2017 Farm Size and Number of Head Lettuce Operations

Farm Size (acres)	Acres Harvested	Number of Operations
0.1–0.9	92	381
1.0–4.9	137	74
5.0–14.9	139	17
15.0–24.9	135	7
25.0–49.9	258	7
50.0–99.9	1,623	24
100–249	7,395	46
250–499	11,009	30
500–749	8,718	14
750–999	6,227	7
≥1,000	66,174	38
Total	101,907	645

Source: U.S. Department of Agriculture (2017).

Payroll costs have also increased in California. In 2016, AB 1513 affected employers of piece-rate workers. The California Labor Code was amended to establish separate wage calculations to compensate for rest or other nonproductive time so as not to penalize workers for taking rest breaks. Additionally, AB 1522—the Healthy Workplace Healthy Families Act of 2014—requires employers to provide paid sick leave for any employee who works 30 or more days within a year, including part-time and temporary workers. Employees earn at least one hour of paid sick leave for every 30 hours worked (California Department of Industrial Relations, 2019).

Perhaps the more costly regulatory changes are those that have yet to be fully implemented. In 2016, California passed SB 3, which mandates an increase in minimum wages to $15/hour by 2022. The increase will be phased in over time; California employers with 26 or more employees were required to pay a minimum of $10.50/hour in 2017 with incremental increases each year thereafter. Employers with 25 or fewer employees have an additional year to phase in the increases. Another state law requiring agricultural workers to receive overtime wages after 40 hours, rather than the current limit of 60 hours, was also passed in 2016. AB 1066 began to change overtime wages in January 2019 such that workers now receive overtime pay after 9.5 hours/day or 55 hours/week. By January 1, 2022, the law will be fully implemented with overtime pay occurring for work exceeding 8 hours/day or 40 hours/week (California Department of Industrial Relations, 2019). These recent laws are expected to pose significant costs to the agricultural industry.

This paper presents a follow-up of a 2006 study of regulatory costs for a large Salinas Valley lettuce grower (Hamilton, 2006). In the months following the original study, an historic *E. coli* outbreak in spinach substantially changed the regulatory landscape for leafy greens food safety with the implementation of the Leafy Greens Marketing Agreement, followed several years later with the Produce Rule of the Food Safety Modernization Act. This follow-up study provides the basis for estimating the impacts of increased agricultural labor costs on head lettuce production given the passage of SB 3.

Head Lettuce Production

We calculate the direct impact of costs associated with new wage policies and estimate their effects on head lettuce production and prices. Hamilton and McCullough (2018) document both the direct cash and indirect costs of regulatory compliance in 2017 and compare them to 2006 costs for the same lettuce grower. The 2006 study found that total regulatory compliance costs totaled $109.16/acre, or 4.25% of cultural costs and 1.26% of total production costs (Hamilton, 2006). In addition, 56% of regulatory costs were associated with labor and wage laws.

In the follow-up case study, labor-related regulatory costs increased from $61.57/acre to $721.57/acre. The increase can be primarily attributed to substantial increases (470%) in workers' compensation premiums, the value of nonproductive time, the time spent completing paperwork associated with each regulation, and the implementation of the Affordable Care Act (ACA). Because of these cost increases and the relatively limited availability of farm labor, California agricultural producers have been substituting capital for labor whenever technology allows for an economical substitution. Head lettuce, unlike other leafy greens, grows too close to the ground for mechanized harvesting using current technologies. Although new technologies are being developed, far fewer capital-labor substitutions have occurred in harvesting head lettuce relative to many other fruit and vegetable crops. The general increase in labor costs and other market effects have caused a fundamental shift in the types of leafy greens grown in California. Figure 2 indicates that leaf lettuce and romaine lettuce acreages have remained relatively flat over the past decade (California Department of Food and Agriculture, 2018). However, head lettuce acreages have declined by 36% over the same period. Some of the reduction may be a function of consumers gravitating toward value-added salad products, many of which can be mechanically harvested. Increased labor costs, however, have probably also contributed to the reduction in head lettuce acreage.

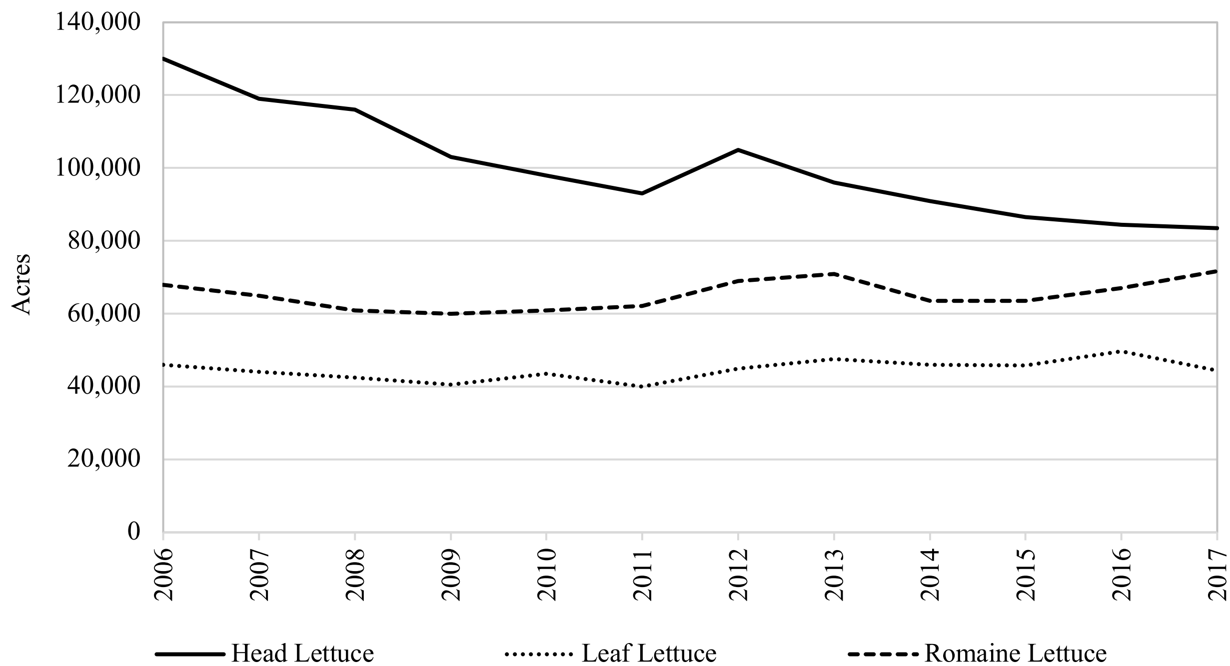

Figure 2. California Harvested Lettuce Acres

Labor costs associated with head lettuce harvesting are sufficiently large that they can exceed a shutdown price, commonly referred to as the "red line" in the lettuce industry. It is increasingly common to see high-quality head lettuce unharvested because harvest costs (for which labor is a major component) exceed lettuce prices. Because of the need for timely harvests, some head lettuce is simply destroyed during the process of preparing soil for the next crop. This is a type of food loss, which is an issue of growing importance as American diets are increasingly scrutinized (Boys and Rickard, 2019).

Table 2 presents total cash head lettuce production costs from a 2017 case study (Hamilton and McCullough, 2018). Seed, chemicals, irrigation, machine and labor cultivation time, harvest costs, and cash overhead costs (land rent, office expenses, and liability insurance attributable to head lettuce production) total nearly $11,000/acre. Approximately half of total cash costs are expenses related to harvesting head lettuce including manual field packing, cooling and palletizing, and marketing and sales fees. These costs total $6.42/carton. If the weekly farmgate price of head lettuce falls below the marginal harvest costs of $6.42/carton, farmers choose to not harvest during that week. Head lettuce that was ready to be harvested during a given week deteriorates to the point that it has to be abandoned. Figure 3 shows the average weekly shipping point price of head lettuce for the last 6 years and average harvest costs per carton as generated by our case study (United States Department of Agriculture Agricultural Marketing Service, 2018). For the 6-year period, there were 11 weeks in which harvest costs exceeded shipping point prices.

Table 2. Head Lettuce Cash Costs per Acre

Operating Costs	Quantity/ Acre	Unit	Price or Cost/Unit	Value or Cost/Acre
Fertilizer				$410.00
Custom				$434.00
Seed				$200.00
Herbicide/insecticide/fungicide				$711.00
Irrigation				$600.00
Machinery				$780.00
Labor				
Equipment operator labor	10.51	hours	$21.85	$229.64
Irrigation labor	13.00	hours	$17.80	$231.40
Non-machine labor	9.52	hours	$16.90	$160.89
Harvest[a]				
Cool/palletize	850.00	cartons	$1.06	$900.00
Harvest-field pack	850.00	cartons	$4.61	$3,922.50
Harvest-market/sales fee	850.00	cartons	$0.75	$637.50
Total operating costs/acre				$9,216.93
Total cash overhead costs/acre				$1,760.00
Total cash costs/acre				$10,976.93

Note: [a]Labor rates do not include regulatory costs associated with piece-rate harvesting labor.

Table 2 and Figure 3 do not account for regulatory costs associated with piece-rate harvesting labor. During the case study interview, regulatory costs associated with labor and wage rates were intentionally separated from the base wage rate so that a pre- and post-regulatory cost comparison could be made. Table 3 presents per acre regulatory costs for the case study grower. Some of the regulatory costs are fixed within a production cycle. Hence, those costs are presented on a per acre (rather than a per carton) basis. However regulatory requirements associated with the ACA, labor health and safety, labor wages, and workers' compensation are also calculated on a per carton basis because they are avoidable costs if harvest does not occur. Assuming harvest occurs, regulatory costs increase head lettuce production by $0.82/carton. When these costs are included, harvest costs exceed shipping costs in 26 weeks over the 6-year time span (Figure 3).

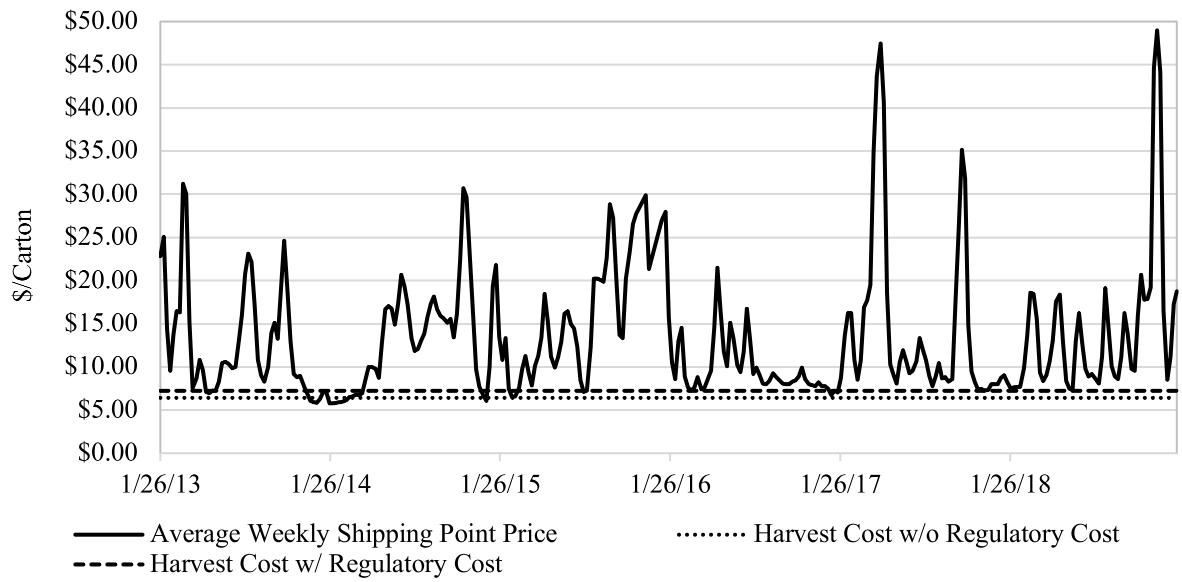

Figure 3. Head Lettuce Shipping Point Price and Average Harvest Cost (Nominal), With and Without Regulatory Costs

Table 3. 2017 Regulatory Costs per Acre and Carton for the Case Study Grower

Regulatory Category	**Per Acre**	**Per Carton**
ACA requirements	$141.19	$0.17
Air quality requirements	$5.26	
Assessments	$14.88	
Department of pesticide regulation	$35.55	
Education/training for regulatory compliance	$26.31	
Food safety - LGMA and PR	$181.48	
Labor health & safety requirements	$28.72	$0.03
Labor wage requirements	$189.10	$0.22
Water quality requirements	$18.57	
Workers' compensation	$336.23	$0.40
Totals	$977.30	$0.82

Note: For a full discussion of the regulatory cost categories and computations, see Hamilton and McCullough (2018).

An Equilbrium Displacement Model

We develop an equilibrium displacement model (EDM) to quantify the impacts of increased labor costs on the price and quantity demanded of head lettuce. The basic EDM is constructed following Atwood and Brester (2019), Gardner (1990), and Wohlgenant (1993) as

(1) $$E(q_d) = \eta_d E(p_d);$$

(2) $$E(p_s) = \sum_j K_j \, E(w_j^d);$$

(3) $$E(x_i^d) = E(q_s) + \sum_j K_j\, \sigma_{ij} E(w_j^d), i = 1,2, \dots, n;$$

(4) $$E(x_i^s) = \sum_j \varepsilon_{ij}\, E\,(w_j^s);$$

where q_d is the quantity demanded of head lettuce, p_d is the consumer demand price of head lettuce, p_s is the producer supply price of head lettuce, q_s is the quantity supplied of head lettuce, x_i^d represents lettuce production sector's quantity demanded for factor inputs, w_j^d represents factor demand prices, x_i^s represents the quantity supplied of factor inputs, w_j^s represents factor supply prices, σ_{ij} is the Hicks–Allen elasticity of substitution between factors i and j, ε_{ij} are own- and cross-price elasticities of factor supplies, η_d is the own-price elasticity of demand for head lettuce, K_j represents factor cost shares ($K_j = \frac{w_j x_j^d}{w x^d}$) such that $\sum_j K_j = 1$, and $E(\cdot)$ represents percentage changes such that $E(\cdot) = \frac{d(\cdot)}{(\cdot)}$. Silberberg (1990) notes that $\sum_j K_j\, \sigma_{ij} = 0$ is necessary to make the system of equations "add up" or, more precisely, be homogeneous of degree 0 in input and output prices. This logical condition is analogous to the concept of a lack of "money illusion" in consumer theory. That is, the homogeneity condition implies that no output response should occur if all input prices were, say doubled, along with the output price. Hence, only relative input and output prices influence production behavior as opposed to absolute prices. In the absence of this condition, EDM outcomes are not consistent with economic theory.

Equation (1) represents the demand for head lettuce and equation (2) represents the supply of head lettuce. Equation (3) represents the production technology used to produce head lettuce in terms of factor inputs, the quantity supplied of lettuce, and factor prices. Equation (4) represents input factor supply functions.

We use the simplifying assumptions that only two inputs are being used (i.e., labor and a composite input representing all other factor inputs) and that factor input supply quantities are functions of only their own-factor prices rather than influenced by the price of the other factor in the system. It seems reasonable to assume that the impact of the price of all other production inputs (w_2) would have a *de minimis* influence on the supply of labor (x_1) and vice versa. Hence, we assume that $\varepsilon_{12} = \varepsilon_{21} = 0$. In addition, head lettuce has a short shelf life, so it is reasonable to assume that an equilibrium price (i.e., $p = p_d = p_s$) clears the market such that the quantities demanded and supplied are equal (i.e., $q = q_d = q_s$). Therefore, a one output, two-factor input EDM for the head lettuce industry can be written as

(5) $$E(q\,) = \eta_D E(p) + E(\theta_1);$$

(6) $$E(p) = K_1 E(w_1) + K_2 E(w_2) + E(\theta_2);$$

(7) $$E(x_1) = E(q) + K_1\sigma_{11} E(w_1) + K_2\sigma_{12} E(w_2) + E(\theta_3);$$

(8) $$E(x_2) = E(q) + K_1\sigma_{21} E(w_1) + K_2\sigma_{22} E(w_2) + E(\theta_4);$$

(9) $$E(x_1) = \varepsilon_1 E(w_1) + E(\theta_5);$$

(10) $$E(x_2) = \varepsilon_2 E(w_2) + E(\theta_6).$$

Equation (5) represents consumer demand for head lettuce in which all arguments other than own-price of output are held constant. Equations (6)-(8) represent the head lettuce sector's aggregate production function and the first-order conditions for the sector's profit maximization problem. Equation (9) represents the supply of labor (factor input 1) and equation (10) represents the supply of all other inputs used in the production of head lettuce (factor input 2).

Equations (5)-(10) represent an EDM that can be used to model several types of exogenous shocks. Specifically, the model can be used to estimate changes in equilibria that result from (positive or negative) shocks to consumer demand (θ_1) and/or input supplies (θ_5, θ_6). Exogenous shocks to production technologies can be modeled using θ_2, θ_3, and θ_4, although these percentage changes are not independent of one another.

Regulatory Wage Policies

Policy-related actions are modeled within an EDM framework by placing a wedge between specific equilibrium conditions. For example, a regulatory action that places a price floor on wages represents a quantity wedge that is placed between the quantity demanded of labor and the quantity supplied of labor as indicated in Figure 4.

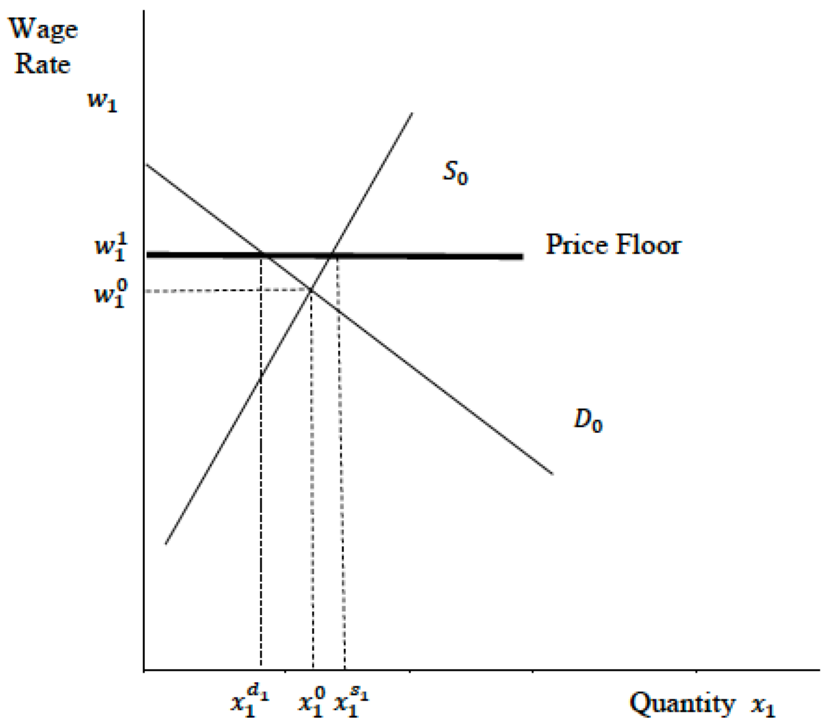

Figure 4. A Price Floor in the Labor Market

That is, prior to the implementation of the wage policies described above, the equilibrium wage rate is given by w_1^0 and the equilibrium quantity demanded and supplied are equal at x_1^0. The new, binding price floor is illustrated by the horizontal solid line at w_1^1 in Figure 4. The price floor generates a difference between the quantity demanded of labor ($x_1^{d_1}$) and the quantity of labor that workers would be willing to supply at the higher wage rate ($x_1^{s_1}$). We note that, in the absence of regulations on the quantity of labor hired, the quantity of labor actually hired will be determined by lettuce producers' derived demand for labor (i.e., $x_1^{d_1}$). The size of the quantity wedge between these two values is endogenously determined by the interaction of supply and demand given the regulatory intervention. The model endogenously determines the size of this wedge (and, hence, the values of $x_1^{d_1}$ and $x_1^{s_1}$) by including an additional constraint. The process is analogous to the use of Lagrangean equations as a means for adding constraints to an optimization process. The addition of a new constraint requires that a new endogenous variable representing the size of the quantity wedge (i.e., the amount of "surplus" labor in the market at the legislated price floor) be added to the system for the purpose of system identification.

The EDM in equations (5)-(10) must be altered to account for the legislated imposition of new wage rate policies. Because these policies create a difference between the quantity demanded and supplied of labor, the term x_1 in equation (7) is changed to x_1^d to reflect the quantity *demanded* of labor by California's head lettuce production sector:

$$(11) \qquad E\left(x_1^d\right) = E(q) + K_1\sigma_{11}E(w_1) + K_2\sigma_{12}E(w_2) + E(\theta_3).$$

Further, the term x_1 in equation (9) is changed to x_1^s to reflect the quantity of labor that workers would be willing to supply at various prices (i.e., the quantity supplied of labor):

$$(12) \qquad E(x_1^s) = \varepsilon_1 E(w_1) + E(\theta_5).$$

The quantity wedge driven between the quantity supplied of labor and the quantity demanded of labor by the minimum wage legislation is represented by

$$(13) \qquad E(x_1^s) = E\left(x_1^d\right) + E(\lambda),$$

where λ is the endogenously determined size of the quantity wedge between x_1^s and x_1^d. Finally, an equation must be added to represent the legislated price floor that generates the wedge between quantity supplied of labor and the quantity demanded of labor:

$$(14) \qquad E(w_1) = E(\theta_8),$$

where $E(\theta_8)$ is the percentage increase in the price of labor resulting from the wage rate legislation.

Head Lettuce Produced Outside of California

California produces 64% of U.S. head lettuce. Arizona produces most of the remainder, with Florida, Mexico, Canada, and Peru contributing modest amounts. Although California and Arizona's seasonal production cycles generally do not coincide, we consider all non-California head lettuce production as an additional sector in the EDM. We assume that the supply of "non-California" head lettuce (q_{nc}) is a function of the price of non-California head lettuce (p_{nc}). Assuming that non-California produced head lettuce is a perfect substitute for California head lettuce, the price of non-California head lettuce is deemed to be identical to the price of California head lettuce which allows for the supply of non-California head lettuce to be written as

(15) $$q_{nc} = q_{nc}(p).$$

Converting equation (15) into a differential elasticity form while assuming that the quantity demanded of head non-California lettuce production is equal to the quantity supplied of non-California head lettuce production yields

(16) $$E(q_{nc}) = \varepsilon_{nc} E(p) + E(\theta_7).$$

The amount of head lettuce available in the United States (q) is now a combination of California production (q_c) plus the quantity of non-California production (q_{nc}):

(17) $$q = q_c + q_{nc}.$$

Totally differentiating equation (17) yields

(18) $$dq = dq_c + dq_{nc}.$$

Dividing each term in equation (18) by q results in

(19) $$\frac{dq}{q} = \frac{dq_c}{q} + \frac{dq_{nc}}{q}.$$

To convert to elasticities and proportional market shares, we multiply the first term on the right side of equation (19) by $\left(\frac{q_c}{q_c}\right)$ and the second term by $\left(\frac{q_{nc}}{q_{nc}}\right)$, which yields

(20) $$\frac{dq}{q} = \left(\frac{q_c}{q}\right)\frac{dq_c}{q_c} + \left(\frac{q_{nc}}{q}\right)\frac{dq_{nc}}{q_{nc}}$$

or

(21) $$E(q) = \mathcal{R}_c E(q_c) + \mathcal{R}_{nc} E(q_{nc}),$$

where $\mathcal{R}_c$ represents California's production quantity share of head lettuce and $\mathcal{R}_{nc}$ represents the quantity share provided by all non-California head lettuce sources. Note that because head lettuce cannot be stored, $\mathcal{R}_c + \mathcal{R}_{nc}$ must sum to 1.0.

The complete EDM consists of equations (5), (6), (11), (8), (21), (16), (12), (10), (13), and (14), giving

(22) $$E(q) = \eta_D E(p) + E(\theta_1);$$

(23) $$E(p) = K_1 E(w_1) + K_2 E(w_2) + E(\theta_2);$$

(24) $$E(x_1^d) = E(q_c) + K_1\sigma_{11}E(w_1) + K_2\sigma_{12}E(w_2) + E(\theta_3);$$

(25) $$E(x_2) = E(q_c) + K_1\sigma_{21}E(w_1) + K_2\sigma_{22}E(w_2) + E(\theta_4);$$

(26) $$E(q) = \mathcal{R}_c E(q_c) + \mathcal{R}_{nc} E(q_{nc});$$

(27) $$E(q_{nc}) = \varepsilon_{nc} E(p) + E(\theta_7);$$

(28) $$E(x_1^s) = \varepsilon_1 E(w_1) + E(\theta_5);$$

(29) $$E(x_2) = \varepsilon_2 E(w_2) + E(\theta_6);$$

(30) $$E(x_1^s) = E(x_1^d) + E(\lambda);$$

(31) $$E(w_1) = E(\theta_8).$$

The EDM model presented in equations (22)–(31) is operationalized by moving the endogenous variables to the left side and then placing the resulting equalities into matrix form:

(32) $$\begin{bmatrix} 1 & -\eta_D & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & -K_1 & -K_2 & 0 & 0 \\ 0 & 0 & 1 & 0 & -1 & 0 & -K_1\sigma_{11} & -K_2\sigma_{12} & 0 & 0 \\ 0 & 0 & 0 & 1 & -1 & 0 & -K_1\sigma_{21} & -K_2\sigma_{22} & 0 & 0 \\ 1 & 0 & 0 & 0 & -\mathcal{R}_c & -\mathcal{R}_{nc} & 0 & 0 & 0 & 0 \\ 0 & -\varepsilon_{nc} & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\varepsilon_1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & -\varepsilon_2 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} E(q) \\ E(p) \\ E(x_1^d) \\ E(x_2) \\ E(q_c) \\ E(q_{nc}) \\ E(w_1) \\ E(w_2) \\ E(x_1^s) \\ E(\lambda) \end{bmatrix} = \begin{bmatrix} E(\theta_1) \\ E(\theta_2) \\ E(\theta_3) \\ E(\theta_4) \\ 0 \\ E(\theta_7) \\ E(\theta_5) \\ E(\theta_6) \\ 0 \\ E(\theta_8) \end{bmatrix}.$$

In a general form, equation (32) can be written as

(33) $$\boldsymbol{Ay} = \boldsymbol{x},$$

where $\boldsymbol{A}$ is a 10×10 matrix of parameters, $\boldsymbol{y}$ is an 10×1 vector of endogenous variables, and $\boldsymbol{x}$ is an 10×1 vector of exogenous shocks. After parameterizing the $\boldsymbol{A}$ matrix, the system's endogenous variables can be solved for any exogenous shock (θ_i) as

$$\boldsymbol{y} = \boldsymbol{A}^{-1}\boldsymbol{x}. \tag{34}$$

Parameterizing the Model

The matrix $\boldsymbol{A}$ is parameterized using an own-price elasticity of demand (η_D) of −0.56 (Mahish, 2018). We use an estimate of the own-price elasticity of labor supply (ε_1) for factor (x_1) of 0.15, which is the simple average of estimates for male and female agricultural laborers (Hill, 2016, 2019). The own-price elasticity of factor supply (ε_2) for input 2 (x_2) is assumed to be highly elastic because lettuce production is a relatively small part of U.S. agricultural capital, herbicide, and machinery input use. We arbitrarily set this value to 10. Based on the per acre cash costs reported in Table 2, the factor shares of x_1 (K_1) and x_2 (K_2) are 0.414 and 0.586, respectively. We also (initially) assume that the Allen elasticities of substitution are $\sigma_{12} = \sigma_{21} = 0.20$, which indicates that the substitution between labor and all other inputs is relatively limited. The assumption is based on the current paucity of mechanical harvesting technologies. Although the terms σ_{11} and σ_{22} have no economic meaning as elasticities of substitution, they must be included in the model if the economic system is to be homogeneous of degree 0 in prices and allow for the system to add up (Silberberg, 1990). These values are calculated as $\sigma_{11} = -\frac{K_2 * \sigma_{12}}{K_1} = -\frac{0.586*0.20}{0.414} = -0.283$ and $\sigma_{22} = -\frac{K_1 * \sigma_{21}}{K_2} = -\frac{0.414*0.20}{0.586} = -0.141$. Because California head lettuce production represents 64% of total U.S. consumption, the value of $\mathcal{R}_c$ is set equal to 0.64 and the value of $\mathcal{R}_{nc}$ is set to 0.36. Using these values, the matrix $\boldsymbol{A}$ in equation (32) is parameterized as

$$\boldsymbol{A} = \begin{bmatrix} 1 & 0.56 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & -0.414 & -0.586 & 0 & 0 \\ 0 & 0 & 1 & 0 & -1 & 0 & 0.12 & -0.12 & 0 & 0 \\ 0 & 0 & 0 & 1 & -1 & 0 & -0.08 & 0.08 & 0 & 0 \\ 1 & 0 & 0 & 0 & -0.64 & -0.36 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -0.15 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & -10.0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix}. \tag{35}$$

The EDM is used to estimate the impacts of an exogenous shock in labor costs resulting from several legislated wage rate policies. That is, SB 3 will increase the minimum wage to \$15/hour by 2022, AB 1513 requires employers to pay for nonproductive time, and AB 1066 will increase overtime pay by reducing normal working hours to 40 hours/week. Although previous wage regulations were nonbinding, wage rates for H-2A immigrant labor in California were legislated to be \$13.18/hour in 2017 and have since risen to \$13.92/hour. Employers who hire H-2A workers must pay all of their workers the same wage, even if only a small portion of the workforce is designated as H-2A workers. SB 3 represents a 17% increase in the current equilibrium wage rate, although this increase will be gradually phased in over several years. Combined with additional piece-rate and overtime rules (estimated to be approximately 3% in the 2017 case study), we consider the impact of a 20% increase in labor wage rates above current equilibrium values. The impact of a 20% increase in wage rates on the endogenous variables is operationalized by setting the value of $E(\theta_8)$ to 0.20 such that the exogenous shock vector becomes

(36) $$\boldsymbol{x} = \begin{bmatrix} 0.0 \\ 0.0 \\ 0.0 \\ 0.0 \\ 0.0 \\ 0.0 \\ 0.0 \\ 0.0 \\ 0.0 \\ 0.20 \end{bmatrix}.$$

Results

Using equation (34) and the exogenous shock indicated in equation (36), a 20% increase in labor costs results in the following percentage changes in the vector of endogenous variables:

(37) $$\boldsymbol{y} = \begin{bmatrix} E(q) \\ E(p) \\ E(x_1^d) \\ E(x_2) \\ E(q_c) \\ E(q_{nc}) \\ E(w_1) \\ E(w_2) \\ E(x_1^s) \\ E(\lambda) \end{bmatrix} = \begin{bmatrix} -0.043 \\ 0.077 \\ -0.136 \\ -0.094 \\ -0.111 \\ 0.077 \\ 0.200 \\ -0.009 \\ 0.030 \\ 0.166 \end{bmatrix}.$$

The interpretation of these results is that a 20% increase in labor costs increases the retail price of head lettuce, $E(p)$, by 7.7%, which reduces the quantity demanded of head lettuce, $E(q)$, by 4.3%. The reduction in head lettuce production (i.e., that which coincides with the reduction in quantity demanded) could be the result of fewer acres planted and/or fewer cartons harvested. In addition, the price of labor, $E(w_1)$, increased by 20.0%, which represents the legislated increase in labor costs above the current equilibrium price. The labor price floor reduces the quantity demanded of labor, $E(x_1^d)$, by 13.6%. For the second (composite) factor, the increase in the price of labor causes the demand for all other inputs, $E(x_2)$, to decline by 9.4%, and the price of all other inputs, $E(w_2)$, to decline by a very small amount (−0.9%). The small decline in the price of all other inputs is the result of the assumed large elasticity of supply for all other inputs (i.e., 10.0). However, the reduction in the demand for this second input is negative rather than positive as would normally be expected for two inputs that are production substitutes. In this case, however, the assumed small elasticity of substitution between the two inputs causes the negative scale effect of lower production to overwhelm the positive (but small) substitution effect between the two factor inputs. Hence, the increase in labor wages causes a reduction in the production of head lettuce that also reduces the demand for the composite input. Although there are some substitution possibilities between labor and all other inputs, they are not sufficiently large to increase the demand for this second factor input.

The production of head lettuce in California, $E(q_c)$, declines by 11.1%, while production of head lettuce that is consumed in the United States from non-California sources, $E(q_{nc})$, increases by 7.7%. Because of the linearity of the EDM, the share weighted changes in production among the two "production regions" equals the overall decline in lettuce consumption (4.3%). Finally, note that the sum of the absolute value of the reduction in quantity demanded of labor (−13.6%) and the increase in the potential quantity supplied of labor (3.0%) is equal to the quantity wedge calculated by the model, $E(\lambda)$, of 16.6%. That is, the size of the quantity wedge that is driven between the quantity demanded and supplied of labor is provided by $E(\lambda)$. The reduction in the quantity demanded of labor is more than twice the increase in the quantity of labor that workers would be willing to supply at the higher wage rate because of the relatively inelastic own-price elasticity of labor supply.

Sensitivity Analyses

The EDM allows for a variety of sensitivity analyses. For example, the decrease in quantity demanded of head lettuce noted above is certainly influenced by estimates of its own-price elasticity of demand. Figure 5 presents the changes in quantity demanded of head lettuce caused by a 20% increase in agricultural wage rates for various demand elasticity estimates. Specifically, the elasticity of demand for head lettuce (η_D) in the parameter matrix $\boldsymbol{A}$ is set to values between −0.05 and −2.0, and equation (34) is solved for each selected elasticity. The results are recorded for each solution ($\boldsymbol{y}$). As the elasticity of demand for head lettuce becomes less inelastic (more elastic), the percentage reduction in quantity demanded increases from 0.4% to 13.8% in response to the wage rate increase.

Alternatively, consider the possibility that other production inputs become more substitutable for labor. Technologies are being developed that will eventually reduce labor requirements needed for the mechanical harvesting of head lettuce. To simulate the effect of such a technological change, we evaluate the impact of a 20% increase in labor wage rates while allowing the elasticity of substitution to vary from 0.0 (the case of fixed input proportions between labor and other inputs) to 3.0. Figure 6 shows that the marginal impact on quantity demanded of head lettuce to be quite small as the elasticity of substitution ranges from 0.0 to 3.0. Note that increases in the elasticity of substitution between labor and all other inputs do not alter the result that increasing wage rates will increase head lettuce prices and reduce the quantity demanded of head lettuce.

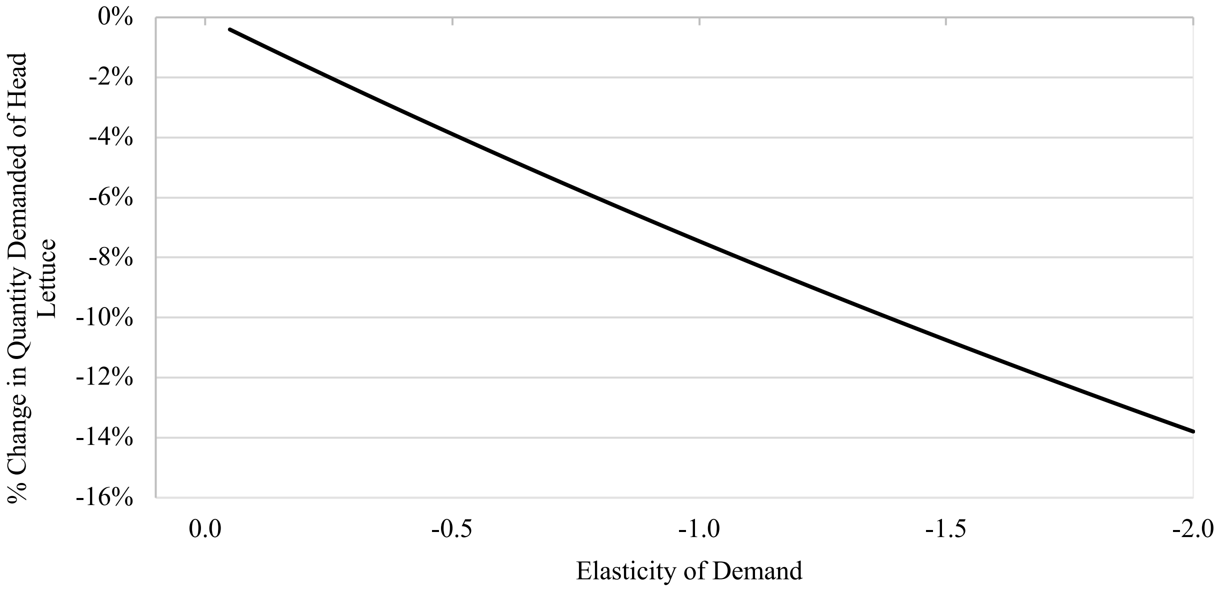

Figure 5. Percentage Decrease in Quantity Demanded of Head Lettuce for Various Own-Price Elasticities of Demand

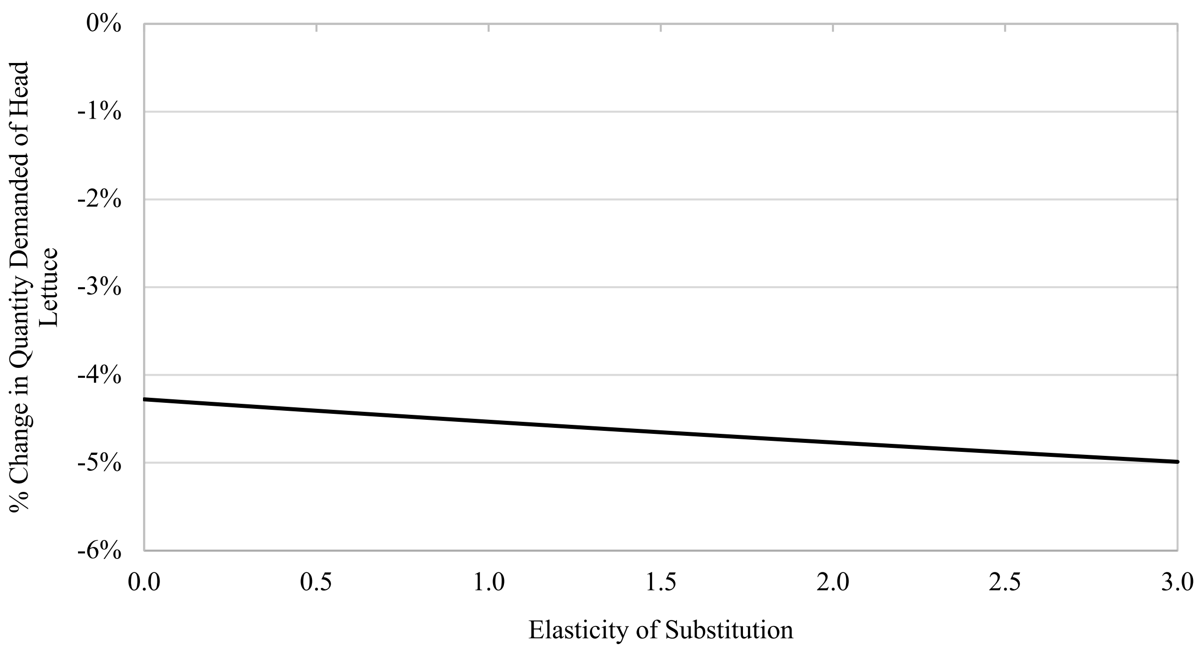

Figure 6. Percentage Decrease in Quantity Demanded of Head Lettuce for Various Elasticities of Factor Input Substitution

Conclusions

The supply of agricultural labor has been declining for many years. In addition, a variety of regulations (especially in California) have increased agricultural labor costs. To the extent possible, increases in labor costs encourage the substitution of other inputs for labor. Alternatively, if such substitution is limited, farmers adjust by switching to less labor-intensive crops.

Agricultural labor costs have been increasing over the past 2 decades. This is especially the case in California, which is the nation's largest fruit and vegetable-producing state. Recent legislation (SB 3, AB 1513, and AB 1066) will increase the minimum hourly wage for farm workers and requirements regarding piece-rate and overtime pay. These actions will increase labor costs, reduce the quantity demanded of labor, and reduce the U.S. production of labor-intensive agricultural products.

We use an equilibrium displacement model to estimate the impact of legislated increases in agricultural wage rates. We find that a 20% increase in agricultural labor wage rates will increase the retail price of head lettuce by 7.7% and reduce the quantity demanded of head lettuce by 4.3%. These effects are not mitigated by larger Allen elasticities of substitution between labor and other inputs.

Increases in labor costs will reduce head lettuce production and cause concomitant increases in the price of head lettuce and reductions in quantity demanded. Given that U.S. consumers already fail to consume the amount of vegetables recommended by the USDA, increases in labor wage rate regulations will exacerbate this deficiency.

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