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The impact of Mexican competition on the U.S. strawberry industry

RESEARCH ARTICLE

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Abstract

This paper models the U.S. strawberry market and examines how increasing imports from Mexico affect the prices and shipment values of California and Florida winter strawberries. The Synthetic Inverse Demand System is used to quantify the impact of Mexican shipments on the prices of strawberries. The estimation results indicate that market prices are responsive to supply from each of the three sources, suggesting an integrated, competitive national market. The simulation results suggest that rapidly growing Mexican shipments will cause large losses to the U.S. strawberry industry, posing challenges to the sustainability and survival of the industry, particularly that of the Florida industry. Policy implications and recommendations for the industry are discussed.

Keywords: competitiveness, Mexican competition, NAFTA, strawberry market, sustainability, synthetic inverse demand system
JEL code: Q11, Q13, Q18

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1. Introduction

The North American Free Trade Agreement (NAFTA) has enabled free movement of commodities in North America and created greater market integration between the U.S. and Mexican produce industries. Geographic proximity and lower cost of production have greatly boosted Mexican exports to the U.S. under NAFTA. In recent years, growing imports from Mexico have created great challenges to the U.S. domestic produce industry. The literature has pointed out that rapidly growing imports have the potential to displace domestic production (Burfisher *et al.*, 2001; Young, 1988). Many domestic produce sectors, such as tomatoes, cucumbers, bell peppers, and strawberries, have found it difficult to compete with produce imported from Mexico (Asci *et al.*, 2016; Wu *et al.*, in press; Zahniser *et al.,* 2015). This study focuses on the strawberry industry to highlight the increasing competition and its impact on the U.S. domestic industry.

As a high-value fruit crop, the total U.S. production value of strawberries amounted to 2.8 billion dollars in 2014, which was more than two times higher than that of fresh tomatoes, one of the highest valued vegetable crops (Wu *et al.*, in press). According to the National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture (USDA), approximately 3.0 billion pounds of strawberries were produced in 2014 (USDA/NASS, 2015). The leading strawberry-producing states are California and Florida. The total amount of strawberries produced in the two states account for about 98% of total U.S. production. In 2014, California produced nearly 2.8 billion pounds of strawberries from 41,500 acres. Florida produced approximately 0.2 billion pounds of strawberries from 10,900 acres.

In addition to the production of California and Florida, Mexico is another major supplier of strawberries in the U.S. market. According to the Foreign Agricultural Service of the USDA, the imported strawberries from Mexico account for about 95% of total imported strawberries in the U.S. market. In 2014, about 300 million pounds were imported from Mexico between November and April. The three suppliers compete in the winter strawberry market. Figure 1 shows the seasonal differences in strawberry production across the three competitors. Florida produces only in the winter season, while California produces year round. California's winter production is mainly in the southern region. Mexican production is mainly in the winter season, similar to that of Florida. The average market shares of the three competitors over 2010-2014 during the winter months (December through March) were 35, 39 and 26% for California, Florida, and Mexico, respectively.

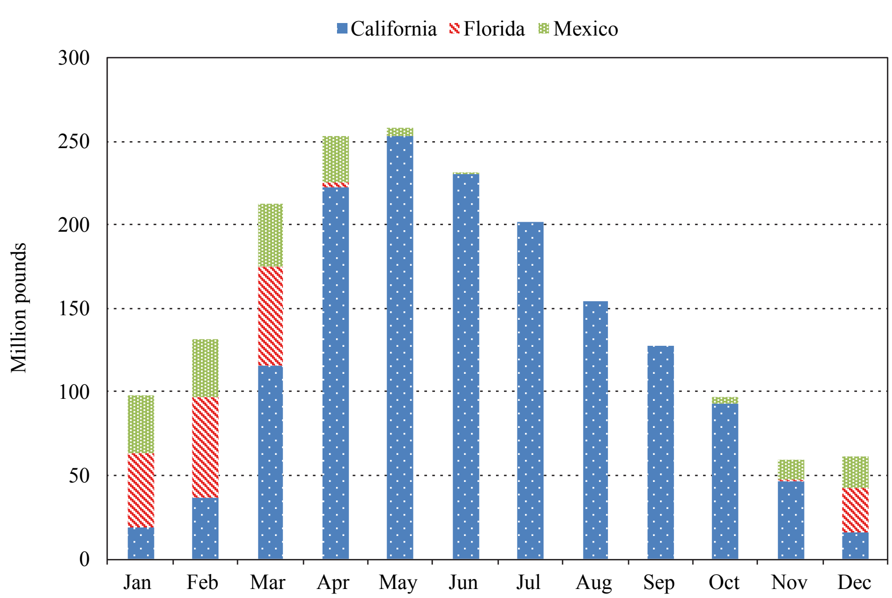

Figure 1. Average monthly shipments of strawberries, 2010- 2014.

In recent years, the U.S. strawberry industry has become increasingly concerned about the strong competition from Mexico. Mexico has surpassed Florida as the largest supplier of winter strawberries in the U.S. market since 2012. In a period of 10 years (2004-2014), imports from Mexico increased fourfold, creating tremendous pressure on Florida growers. As a result, the production value of Florida strawberries slumped from 370 million dollars in 2010 to 201 million dollars in 2012 (USDA/NASS, 2013). The competition from Mexico, along with labor shortages and increasing production costs (e.g. Baker, 2004; Carter *et al.*, 2005; Goodhue *et al.*, 2005; Johnson, 2014; Norman, 2005), is posing a great challenge to the U.S. winter strawberry industry. In Florida, the largest U.S. winter strawberry producing state, the labor cost of domestic strawberries is about $9,000 per acre, which accounts for about 40% of farm-gate sales (Guan *et al.*, 2015). Moreover, it is increasingly difficult to find enough labor in the harvesting season as more Mexican immigrants are returning to Mexico due to the increased employment opportunities in the Mexican economy (Taylor *et al.*, 2012) and stricter immigration policies.

Admittedly, the U.S. producers have comparative advantages in breeding technology and have better infrastructure and extension services. But the growing production capacity of the Mexican industry has kept putting pressure on the U.S. strawberry industry. Over the years, the Mexican government has been promoting and subsidizing its horticulture industry, which has intensified since 2009 with the introduction of its strategic project for protected agriculture (Victoria *et al.*, 2011). In 2013, Mexico proposed to further double the production capacity of its strawberry industry in the coming years (Guan *et al.*, 2015). A significant increase in Mexican production capacity will pose further challenges to the U.S. winter strawberry industry, particularly the Florida industry.

In the literature, economic analyses that focus on strawberries are limited. Wu *et al.* (2015) identified the optimal yield distribution over the season to maximize profit for Florida growers given California and Mexico's supply pattern, providing information to support breeders in developing cultivars of more economic value to growers. Lee and Kennedy (2016) conducted a partial equilibrium analysis to study the trade creation and diversion effect of NAFTA in the strawberry market. The present paper investigates the impact of imports on the U.S. strawberry market and industry sustainability. The contribution of this paper is twofold. First, the paper models the effects of shipments of California, Florida, and Mexican strawberries on shipping prices the industry receives. Second, this paper further quantifies how growing imports from Mexico will affect the U.S. strawberry industry by simulating shipping prices and shipment values (market shares) of U.S. strawberries under different growth scenarios. This information is then used to assess the loss caused to the industry under these scenarios.[1] The empirical findings in this paper will provide strawberry producers and policy makers with important insights on the challenges and the sustainability of the U.S. strawberry industry. The case of the strawberry industry will also shed light on the impact of Mexican competition on the U.S. fresh produce industry under the NAFTA.

The paper is organized as follows. The next section presents the Synthetic Inverse Demand System (SIDS) approach used in this study, and discusses its application to the U.S. strawberry market. The following sections present data descriptions and estimation results of the scale elasticities and price flexibilities, followed by simulations of the effects of Mexican shipments on the prices and shipment values of U.S. domestic strawberries. The final section concludes and discusses the sustainability and the future of the U.S. strawberry industry.

[1] The U.S. is a large importer of strawberries; its exports are small relative to the total imports and its total production. Export to Mexico accounts for roughly 1% of the U.S. production (or 10% of U.S. total export) over the last few years according to the U.S. Department of Commerce statistics. In this study, we focus on fresh strawberries. There are processed or frozen strawberries, but the market share is small and economically insignificant compared to fresh strawberries.

2. The synthetic inverse demand system

In general, inverse demand systems are considered suitable to estimate the demand for fresh food due to its perishable nature (Brown *et al.* 1995; Chambers and McConnell, 1983; Eales and Unnevehr, 1993, 1994; Grant *et al.,* 2010; Huang, 1988; Matsuda, 2005; Park and Thurman, 1999; Park *et al.,* 2004). In most inverse demand systems, quantities supplied are considered to be predetermined by production at the market level.[2] Strawberries are highly perishable with a limited shelf life. After harvest, they are sorted and stored in cold rooms at 0-10 °C, and then sold within approximately 7-10 days to meet the commercially-acceptable quality (Ayala-Zavala *et al.*, 2004; Hernandez-Munoz *et al.*, 2008). In Florida, freshly picked strawberries are usually shipped within 24 hours. For the demand analysis of perishable strawberries, the SIDS developed by Brown *et al.* (1995) is used to examine the responsiveness of the prices of perishable strawberries to the changes in quantities. In particular, the SIDS is used to assess the effects of the shipments of California, Florida, and Mexican strawberries on the prices in terms of scale elasticities and price flexibilities. The SIDS nests different inverse demand systems and allows for hypothesis testing among systems in empirical applications. This section briefly presents the SIDS approach.

Following Brown *et al.* (1995), we denote $p=(p_1,...,p_n)$ as the vector of nominal prices, $q=(q_1,...,q_n)'$ as the vector of quantities consumed, $m=p'q$ as the total expenditure or income, and $\pi=(\pi_1,..., \pi_n)'\equiv p/m$ as the normalized price vector. A consumer is assumed to maximize the utility, $u=u(q_1,...,q_n)$ subject to the budget constraint, $m=p'q$. The compensated inverse demand function is derived from a distance function, $d(u,q)$ where u is the utility level and q is a consumption bundle of n commodities. The distance function is assumed linearly homogeneous, concave, non-decreasing in quantities, and decreasing in utility, which determines whether quantities decrease or increase to reach a specific utility level. Differentiating the distance function with respect to quantity yields

$$\pi_i = \frac{\partial d(u,q)}{\partial q_i} = \pi_i\,(u,q) \tag{1}$$

for i=1,...,n. Totally differentiating Equation 3 yields

$$d\pi_i = \frac{\partial \pi_i}{\partial u}\,du + \sum_{j=1}^{n} \frac{\partial \pi_i}{\partial q_j}\,q_j \tag{2}$$

for i=1,...,n. In Equation 2, the first term represents the scale effects, and the second term represents the Antonelli substitution effects. When we define q^* as a reference bundle so that $q=kq^*$ where k is a positive scalar, the first term becomes

$$\pi_i = \frac{\partial \ln \pi_i}{\partial \ln k} \sum_{j=1}^{n} s_j d\ln q_j \tag{2a}$$

where $s_i=\pi_i q_i$ is the expenditure or budget share of commodity i (see Brown *et al.* (1995) for detailed derivation). Multiplying Equation 2 by q_i yields the Rotterdam Inverse Demand System (RIDS) proposed by Barten and Bettendorf (1989) as

$$s_i d\ln\pi_i = \alpha_i d\ln Q + \sum_{j=1}^{n} \alpha_{ij} d\ln q_j \tag{3}$$

for i=1,...,n where $d\ln Q\equiv\sum_j s_j d\ln q_j$ is the Divisia volume index, and the parameters, α_i and α_{ij}, represent the scale and substitution effects, respectively. The regularity conditions are imposed on these parameters: adding up ($\sum_i \alpha_i$=–1 and $\sum_i \alpha_{ij}$=0), homogeneity ($\sum_j \alpha_{ij}$=0), and symmetry ($\alpha_{ij}=\alpha_{ji}$).

[2] The perishable nature of strawberries allows us to regard the quantities produced as the quantities available to be consumed in the market. When the quantities supplied are considered to be predetermined, the prices of strawberries are determined by the quantities demanded by consumers.

Other parameterizations also generate different inverse demand systems from the RIDS. Let $d\ln P \equiv \sum_i s_i \ln p_i$ denote the Divisia price index so that $d\ln m = d\ln P + d\ln Q$. Adding $s_i d\ln Q$ to both sides of Equation 3 yields the Laitinen-Theil Inverse Demand System (LTIDS) as

$$s_i d\ln\left(\frac{p_i}{P}\right) = \beta_i d\ln Q + \sum_{j=1}^{n} \alpha_{ij} d\ln q_j \tag{4}$$

for i=1,...,n where $\beta_i = s_i + \alpha_i$. Equation 4 follows from the relationship of $d\ln\pi_i + d\ln Q = d\ln p_i - d\ln P$. The LTIDS is a variant of the RIDS with $\alpha_i = \beta_i - s_i$.

In addition, the differential form of the linear approximation of the Almost Ideal Inverse Demand System (AIIDS) is derived by adding $s_i(d\ln q_i - d\ln Q)$ to both sides of Equation 4. Since $s_i(d\ln p_i + d\ln q_i - d\ln m) = ds_i$, the AIIDS proposed by Eales and Unnevehr (1994) is written as

$$ds_i = \beta_i d\ln Q + \sum_{j=1}^{n} \beta_{ij} d\ln q_j \tag{5}$$

for i=1,...,n. In Equation 5, $\beta_{ij} = \alpha_{ij} + s_i(\delta_{ij} - s_j)$ where δ_{ij} denotes the Kronecker delta, which is equal to unity if $i=j$ and zero otherwise. The AIIDS is a variant of the RIDS with $\alpha_i = \beta_i - s_i$ and $\alpha_{ij} = \beta_{ij} - s_i(\delta_{ij} - s_j)$.

Lastly, another differential inverse demand system is obtained by subtracting $s_i d\ln Q$ from both sides of Equation 5 so that

$$ds_i - s_i d\ln Q = \alpha_i d\ln Q + \sum_{j=1}^{n} \beta_{ij} d\ln q_j \tag{6}$$

for i=1,...,n. Equation 6 is referred to as the Rotterdam Almost Ideal Inverse Demand System (RAIIDS) that has the RIDS scale effects and the AIIDS quantity effects (Brown *et al.,* 1995).

Based on the approach of Brown *et al.* (1995), the SIDS is developed to nest the RIDS, the LTIDS, the AIIDS, and the RAIIDS. Since the four alternative differential inverse demand systems have identical right-side variables, the SIDS is written as

$$s_i d\ln\pi_i = (e_i - d_1 s_i) d\ln Q + \sum_{j=1}^{n} [e_{ij} - d_2 s_i(\delta_{ij} - s_j)] d\ln q_j \tag{7}$$

for i=1,...,n. Equation 7 is constructed by the weighted average of the systems so that $e_i = (1-d_1)\alpha_i + d_1\beta_i$ and $e_{ij} = (1-d_2)\alpha_{ij} + d_2\beta_{ij}$. In Equation 7, e_i and e_{ij} are parameters to be estimated and used to calculate scale elasticities and price flexibilities. The economic regularity conditions require that the parameters satisfy adding up ($\sum_i e_i = -1 = d_1$ and $\sum_i e_{ij} = 0$), homogeneity ($\sum_j e_{ij} = 0$), and symmetry ($e_{ij} = e_{ji}$) conditions. The alternative forms of the differential inverse demand systems are retrieved by restricting d_1 and d_2. The SIDS becomes the RIDS when $(d_1,d_2)=(0,0)$, the LTIDS when $(d_1,d_2)=(1,0)$, the AIIDS when $(d_1,d_2)=(1,1)$, and the RAIIDS when $(d_1,d_2)=(0,1)$. The SIDS nests these four different inverse demand systems and allows hypothesis tests among the systems in empirical applications (Brown *et al.,* 1995). In our empirical application, the shipping-point prices and market shares of strawberries supplied by each strawberry industry are used to construct the dependent variable, while the quantities of strawberries shipped by each strawberry industry are used for the explanatory variables. In addition, the Divisia volume index used for the explanatory variable is constructed by the sum of the market share times each quantity volume.

3. Empirical analysis

3.1 Data and estimation results

Data on prices and quantities of fresh strawberries from California, Florida, and Mexico were obtained from the Agricultural Marketing Service of the USDA. The quantities of strawberries used in this analysis represent shipment volumes measured in million pounds, and their prices indicate shipping-point prices measured in dollars per pound (Table 1). The data for California strawberries include the shipments from Santa Maria, Orange and San Diego, and Oxnard Districts, while those for Florida are predominantly the shipments from central Florida. The data for Mexican strawberries represent the cross-border shipments from Mexico. As shown in Table 1 and Figure 1, Florida and Mexico have lower prices than California because of the heavy competition between them in the winter season.

The data studied in this analysis covers the sixteen-week winter production period, from the second week in December through the fourth week in March for 2010-2014. The period between December and March covers the peak harvesting and marketing period of winter strawberries, particularly for Florida and Mexican strawberries (Figure 2). To account for seasonality, we take differences between observations in a 16-week cycle in Equation 7 (Brown *et al.,* 1995). In addition, the variables are tested for unit roots, cointegration, and structural breaks but we found no statistical evidence of unit roots, cointegration, or structural breaks in the variables.

Table 1. Descriptive statistics of weekly data by source, Dec. 2010-Mar. 2014 (data provided by Agricultural Marketing Service from the U.S. Department of Agriculture; https://www.ams.usda.gov).

	Variables	Mean	Std. dev.	Min	Max
Quantity (million pounds)	California shipment	11.195	11.199	0.163	53.961
	Florida shipment	12.299	6.400	0.783	24.197
	Mexico shipment	7.729	3.050	2.284	16.170
Price (dollars per pound)	California price	2.039	0.627	1.305	3.709
	Florida price	1.682	0.774	0.800	3.550
	Mexico price	1.660	0.684	0.844	3.250

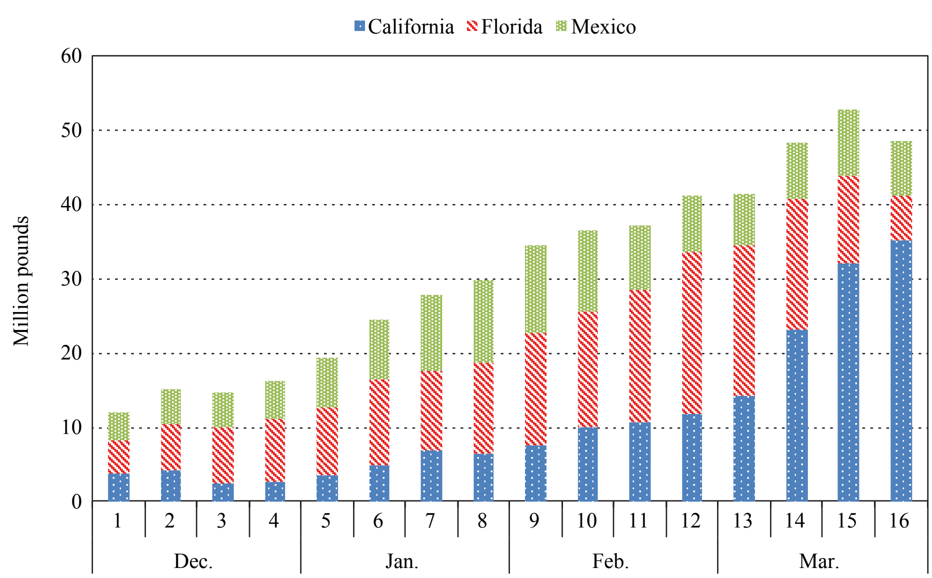

Figure 2. Average weekly shipments of strawberries, 2010-2014.

The system specified in Equation 7 is conditional on the expenditure on strawberries. Following the multistage budgeting approach, we assume separability of utility so that U.S. consumers allocate total expenditure among groups of commodities, strawberries being one of them (Seale *et al.,* 1992, 2003; Yang and Koo, 1994). Within the group of strawberries, U.S. consumers further select products from different sources. Since qualities of agricultural products vary with production regions, we differentiate strawberries shipped from different sources and construct three equations for (1) California; (2) Florida; and (3) Mexico. Distinguishing the supplying sources also allows for varying effects on prices, which may result due to different degrees of market integration or segmentation for strawberries shipped from different suppliers. Dropping the equation for Mexican strawberries to avoid the singularity of the variance-covariance matrix, we estimate the SIDS using the Iterated Seemingly Unrelated Regression (Zellner, 1962). Homogeneity and symmetry are imposed to improve the predictive power of the demand system (Kastens and Brester, 1996).

Table 2 reports the results of the likelihood-ratio (LR) tests for the nested systems. The LR tests are used to compare the SIDS with the nested demand systems. The test results show that the RIDS, the AIIDS, and the RAIIDS are rejected against the SIDS. The LTIDS is not rejected in favor of the SIDS at conventional significance levels. Accordingly, the SIDS is chosen to obtain accurate estimates for scale elasticities and price flexibilities. The estimation results of the SIDS are reported in Table 3. The log-likelihood value is 198.08 and the estimates for d_1 and d_2 are 0.95 and 0.15, respectively, which means that our model is different from the RIDS but close to the LTIDS. The estimated parameters of the equation for Mexican strawberries and their associated standard errors are calculated by the adding-up restrictions.

Table 2. Likelihood-ratio (LR) test statistics for nested systems.[1,2]

Systems	d_1	d_2	Log-likelihood values	LR test statistics
RIDS	0	0	155.171	85.82
LTIDS	1	0	196.471	3.22
AIIDS	1	1	167.052	62.06
RAIIDS	0	1	135.903	124.36

[1] The Likelihood-Ratio test statistic follows a chi-squared distribution.

[2] RIDS = Rotterdam Inverse Demand System; LTIDS = Laitinen-Theil Inverse Demand System; AIIDS = Almost Ideal Inverse Demand System; RAIIDS = Rotterdam Almost Ideal Inverse Demand System..

Table 3. Iterated Seemingly Unrelated Regression estimates of parameters for the Synthetic Inverse Demand System.[1]

	Nesting parameters	Scale parameters	Price parameters		
			California	Florida	Mexico
California price		0.027 (0.024)	0.016 (0.017)	-0.014 (0.012)	-0.002 (0.007)
Florida price		-0.037 (0.042)		0.029 (0.019)	-0.015 (0.008)
Mexico price		-0.041 (0.020)			0.017 (0.014)
d_1	0.949 (0.078)				
d_2	0.150 (0.091)				
Log-likelihood	198.082				

[1] Numbers in parentheses are standard errors.

3.2 Scale elasticities

Using the estimates of the SIDS, we calculate scale elasticities (ε) that represent the extent to which strawberry prices respond to proportional changes in strawberry shipments. The scale elasticity of strawberries shipped from source i is calculated by

$$\varepsilon_i = \frac{e_i}{\bar{s}_i} - 1 \tag{8}$$

where e_i is the parameter estimated from Equation 7, and $\bar{s}_i$ is the sample mean of the share of strawberries shipped from source i. The scale elasticity shows the percentage change in the shipping-point prices in response to a 1% increase in the aggregate shipments of strawberries. Since homothetic preferences require that all expenditure elasticities be equal to one, strawberry is considered scale flexible (inflexible) when a scale elasticity is greater (less) than -1.

The estimated scale elasticities are calculated using Equation 8 and reported in Table 4. All the estimates are negative and statistically significant at 1% significance level, showing that an increase in the shipment scale reduces strawberry prices. The estimates represent that a 1% increase in the aggregate shipments of strawberries will result in decreases in the prices of California, Florida, and Mexican strawberries by 0.87, 1.05 and 1.11%, respectively. When evaluated at the sample mean of the data, the results imply reductions of 1.78, 1.76, and 1.84 cents per pound in the prices of California, Florida, and Mexican strawberries, respectively. The scale elasticity of -1 represents that the market share of shipment value is constant when the scale changes. Our results imply that the shipment value of California strawberries slightly decreases with respect to an increase in the scale, whereas those of Florida and Mexican strawberries slightly increase with increased shipment scale.

3.3 Price flexibilities

Price flexibilities (f) represent the percentage changes in strawberry prices induced by a 1% change in strawberry shipments (Brown *et al.,* 1995). While the compensated price flexibility (f^*_{ij}) of strawberry i with respect to strawberries shipped from a source j is calculated by $f^*_{ij} = e_{ij}/\bar{s}_i - d_2(\delta_{ij} - \bar{s}_j)$, the uncompensated price flexibility (f_{ij}) is

$$f_{ij} = f^*_{ij} + \bar{s}_j \varepsilon_i \tag{9}$$

where δ_{ij} is the Kronecker delta that equals one if $i=j$ and $\bar{s}_i$ is the sample mean of the share of strawberries shipped from source i. The own-price flexibilities represent the percentage change in the price of strawberry of source i when its own shipment changes by 1%. The cross-price flexibilities represent the percentage change in the price of strawberry of source i when the shipment from source j changes by 1%. They are gross quantity-substitutes (quantity-complements) if the cross-price flexibility is negative (positive).

Table 4. Scale elasticities and price flexibilities.[1]

	Scale elasticities	Price flexibilities		
		California	Florida	Mexico
California price	-0.873 (0.042)	-0.364 (0.024)	-0.317 (0.026)	-0.193 (0.019)
Florida price	-1.046 (0.045)	-0.355 (0.021)	-0.421 (0.030)	-0.270 (0.022)
Mexico price	-1.107 (0.037)	-0.351 (0.017)	-0.428 (0.023)	-0.329 (0.043)

[1] Numbers in parentheses are standard errors; all estimates are statistically significant at the 1% significance level.

3.4 Price responses to shipments from different sources

Table 4 presents the estimated price flexibilities based on Equation 9. The diagonal elements show the own-price flexibilities, and the off-diagonal elements show the cross-price flexibilities. The estimated own-price flexibilities are negative and statistically significant at the 1% significance level. The results indicate that the prices of strawberries are not very flexible to own-shipment changes. The own-price flexibility of Florida strawberries is the greatest (-0.42), but the absolute values are less than 1. When evaluated at the sample mean of the data, the Florida strawberry price decreases by 5.76 cents per pound with respect to a 1-million-pound increase in the weekly shipment. In addition, the own-price flexibilities of California and Mexican strawberries show that a 1% increase in own shipments leads to 0.36 and 0.33% reductions in the prices of California and Mexican strawberries, respectively. That is, when California and Mexico increase their shipments by 1 million pounds, the corresponding own prices will decrease by about 6.63 and 7.07 cents per pound, respectively.

Moreover, the estimated cross-price flexibilities are all negative and statistically significant at the 1% significance level, suggesting substitutable, competitive relationships among the strawberries shipped from California, Florida, and Mexico. The estimated cross-price flexibilities are inflexible, indicating prices are relatively less sensitive to shipments from other sources. The low cross-price flexibilities may be attributed to the geographical market segmentation and/or product differentiation. For instance, an increase in California shipments reduces the prices of Florida and Mexican strawberries by 0.36 and 0.35%, respectively, implying that a 1-million-pound increase in California shipments will reduce the prices of Florida and Mexican strawberries by 5.33 and 5.21 cents per pound, respectively, when evaluated at the sample mean. Similarly, an increase in Florida shipments reduces the prices of California and Mexican strawberries by 0.32 and 0.43%, respectively, implying the prices of California and Mexican strawberries will decrease by 5.26 and 5.78 cents per pound in response to a 1-million-pound increase in Florida shipments. While the effects of California shipments on Florida and Mexican prices are very similar, the effect of Florida shipments on Mexican prices are greater than that of California shipments because Florida strawberries compete mainly with Mexican strawberries in the market during the winter season. Furthermore, the estimated cross-price flexibilities show that a 1% increase in Mexican shipments reduces the prices of California and Florida strawberries by 0.19 and 0.27%, respectively. That is, the prices of California and Florida strawberries will decrease by 5.09 and 5.88 cents per pound, respectively, with respect to a 1-million-pound increase in weekly Mexican shipments. The effects of Mexican shipments on the prices of California and Florida are significant.

3.5 Impact of growing imports on the U.S. strawberry industry

Given the U.S. strawberry industry's concerns about growing imports from Mexico, it is worth evaluating the potential impact of increasing Mexican shipments on the future of the U.S. strawberry industry under different growth scenarios. Specifically, we investigate how increasing Mexican shipments affect the prices and shipment values of domestic strawberries *if* the Mexican production capacity and shipments grow by 25, 50, and 100%, respectively. To analyze the impact, we calculate the point estimates of price flexibilities using the average shares of weekly shipment values over the sample period. In Tables 5 and 6, we present the simulated weekly prices and shipment values of California and Florida strawberries under the three scenarios, assuming California and Florida producers maintain their shipment levels. Note that our simulation is based on the static analysis on the U.S. strawberry industry that does not consider potential industry responses or adjustments to increasing Mexican shipments that could occur over time (for example reducing acreage and shipments or adopting new technologies); in other words, we disentangle trade impact holding non-trade factors constant, and show the potential losses for the U.S. strawberry industry if Mexican shipments increase.

Table 5 presents how much Mexican shipments lead to changes in the prices and shipment values of California strawberries in each week from December to March. In the baseline scenario, the shipments of California strawberries grow from December to March, while their prices diminish over the period. Due to the increasing shipments in this period, California has greater shipment values in March than in December.

Table 5. Weekly effects of Mexican shipments on prices and shipment values of California strawberries.[1]

Month/ Week		Baseline			Scenario 1		Scenario 2		Scenario 3	
		Quantity (million lbs.)	Price ($/lb.)	Value (million $)	Price ($/lb.)	Value (million $)	Price ($/lb.)	Value (million $)	Price ($/lb.)	Value (million $)
Dec.	1	3.868	2.936	11.357	2.766	10.700 (-0.66)	2.596	10.042 (-1.31)	2.257	8.728 (-2.63)
	2	4.155	3.034	12.606	2.880	11.964 (-0.64)	2.725	11.322 (-1.28)	2.416	10.038 (-2.57)
	3	2.332	2.663	6.210	2.521	5.878 (-0.33)	2.378	5.546 (-0.66)	2.093	4.881 (-1.33)
	4	2.676	2.235	5.981	2.116	5.663 (-0.32)	1.997	5.345 (-0.64)	1.759	4.708 (-1.27)
Jan.	5	3.518	2.388	8.400	2.252	7.921 (-0.48)	2.115	7.441 (-0.96)	1.843	6.483 (-1.92)
	6	4.790	2.224	10.652	2.094	10.027 (-0.62)	1.963	9.402 (-1.25)	1.702	8.153 (-2.50)
	7	6.807	2.113	14.382	1.977	13.456 (-0.93)	1.841	12.529 (-1.85)	1.568	10.676 (-3.71)
	8	6.337	1.937	12.278	1.819	11.530 (-0.75)	1.701	10.782 (-1.50)	1.465	9.286 (-2.99)
Feb.	9	7.557	1.828	13.816	1.728	13.060 (-0.76)	1.628	12.304 (-1.51)	1.428	10.792 (-3.02)
	10	10.004	1.813	18.141	1.726	17.268 (-0.87)	1.639	16.394 (-1.75)	1.464	14.648 (-3.49)
	11	10.694	1.649	17.636	1.582	16.919 (-0.72)	1.515	16.203 (-1.43)	1.381	14.769 (-2.87)
	12	11.697	1.662	19.436	1.604	18.767 (-0.67)	1.547	18.098 (-1.34)	1.433	16.761 (-2.67)
Mar.	13	14.265	1.682	23.987	1.629	23.238 (-0.75)	1.577	22.489 (-1.50)	1.472	20.991 (-3.00)
	14	23.088	1.546	35.705	1.501	34.655 (-1.05)	1.456	33.606 (-2.10)	1.365	31.507 (-4.20)
	15	32.076	1.478	47.405	1.434	45.990 (-1.41)	1.390	44.575 (-2.83)	1.301	41.746 (-5.66)
	16	35.259	1.434	50.548	1.393	49.117 (-1.43)	1.352	47.685 (-2.86)	1.271	44.821 (-5.73)
Sum				308.539		296.15 (-12.39)		283.76 (-24.78)		258.99 (-49.55)

[1] Scenarios 1 through 3 present the simulated prices and shipment values when Mexican shipments increase by 25, 50 and 100%, respectively.

The simulation results presented in scenarios 1 through 3 show the impact of Mexican shipments on prices in December is greater, which occurs when California supply is relatively low in the market. In scenarios 1 and 2, the reduced prices will reduce the total shipment values of California strawberries by 12.39 and 24.78 million dollars, respectively. That is, the California industry will lose 4.01 and 8.03% of its total shipment value if Mexican shipments increase by 25 and 50%, respectively (Table 7). When Mexico doubles the shipments as in scenario 3, it will cause a total loss of 49.56 million dollars for the California strawberry industry between December and March (i.e. 16.06% of the total shipment value). To put it in perspective, assuming an average yield of 4,000 flats (32,000 lbs) per acre, a rough yield estimate for California winter fresh strawberries, farm revenue will be reduced by $2,213, $4,426, and $8,852 per acre under the three scenarios, respectively, which represent significant losses for strawberry growers (Table 7).[3]

Table 6 reports the impacts of Mexican shipments on the prices and shipment values of Florida strawberries. In the baseline scenario, the shipments of Florida strawberries gradually grow, hitting the peak in the last week of February. The shipment values peak in the third week of February. Under scenarios 1 and 2, the shipment values decrease by 20.16 and 40.33 million dollars, respectively. That is, the Florida industry will lose 6.87 and 13.74% of the total shipment value. Assuming a typical average yield of 3,000 flats (24,000 lbs) per acre for Florida strawberries, scenarios 1 and 2 will result in a revenue loss of $2,460 and $4,919 per acre, respectively (Table 7). The simulation results suggest that Mexican shipments have higher effects on the Florida strawberry industry than on the California industry due to the fact that Florida and Mexico have the same production window and supply pattern.

[3] The per-acre loss estimates are calculated using price differences between the baseline scenario and corresponding scenarios and assuming a yield distribution that follows the pattern of the aggregate industry shipments over the season (see Table 5).

Table 6. Weekly effects of Mexican shipments on prices and shipment values of Florida strawberries.[1]

Month/Week		Baseline			Scenario 1		Scenario 2		Scenario 3	
		Quantity (million lbs.)	Price ($/lb.)	Value (million $)	Price ($/lb.)	Value (million $)	Price ($/lb.)	Value (million $)	Price ($/lb.)	Value (million $)
Dec.	1	4.369	2.988	13.053	2.744	11.988 (-1.07)	2.500	10.923 (-2.13)	2.012	8.793 (-4.26)
	2	6.367	3.020	19.228	2.806	17.867 (-1.36)	2.592	16.506 (-2.72)	2.165	13.784 (-5.44)
	3	7.606	2.238	17.018	2.069	15.737 (-1.28)	1.901	14.456 (-2.56)	1.564	11.894 (-5.12)
	4	8.443	2.081	17.573	1.925	16.256 (-1.32)	1.769	14.939 (-2.63)	1.458	12.306 (-5.27)
Jan.	5	9.168	1.909	17.505	1.758	16.115 (-1.39)	1.606	14.725 (-2.78)	1.303	11.945 (-5.56)
	6	11.673	1.863	21.740	1.711	19.970 (-1.77)	1.559	18.199 (-3.54)	1.256	14.658 (-7.08)
	7	10.696	1.878	20.089	1.708	18.272 (-1.82)	1.538	16.456 (-3.63)	1.199	12.822 (-7.27)
	8	12.389	1.613	19.977	1.476	18.284 (-1.69)	1.339	16.591 (-3.39)	1.066	13.205 (-6.77)
Feb.	9	15.089	1.425	21.501	1.317	19.878 (-1.62)	1.210	18.254 (-3.25)	0.995	15.006 (-6.49)
	10	15.701	1.363	21.393	1.271	19.961 (-1.43)	1.180	18.529 (-2.86)	0.998	15.665 (-5.73)
	11	17.754	1.316	23.358	1.242	22.043 (-1.31)	1.167	20.728 (-2.63)	1.019	18.098 (-5.26)
	12	22.009	1.019	22.421	0.969	21.336 (-1.09)	0.920	20.250 (-2.17)	0.821	18.079 (-4.34)
Mar.	13	20.235	1.066	21.563	1.017	20.578 (-0.99)	0.968	19.592 (-1.97)	0.871	17.622 (-3.94)
	14	17.577	1.071	18.824	1.020	17.927 (-0.90)	0.969	17.030 (-1.79)	0.867	15.235 (-3.59)
	15	11.854	1.027	12.169	0.965	11.440 (-0.73)	0.904	10.712 (-1.46)	0.781	9.254 (-2.91)
	16	5.856	1.034	6.058	0.965	5.653 (-0.41)	0.896	5.247 (-0.81)	0.758	4.437 (-1.62)
Sum				293.469		273.30 (-20.17)		253.14 (-40.33)		212.80 (-80.67)

[1] Scenarios 1 through 3 present the simulated prices and shipment values when Mexican shipments increase by 25, 50 and 100%, respectively.

Table 7. Total industry loss and reduction in net return per acre.

	California		Florida	
	Total loss (million $)	Reduction in net return ($/acre)	Total loss (million $)	Reduction in net return ($/acre)
Scenario 1 (25%)	12.39 (4.01%)	2,213	20.16 (6.87%)	2,460
Scenario 2 (50%)	24.78 (8.03%	4,426	40.33 (13.74%)	4,919
Scenario 3 (100%)	49.56 (16.06%)	8,852	145.29 (49.51%)	8,923

When Mexican shipments are doubled in scenario 3, the Florida total loss due to price difference over the sample period would be 80.67 million dollars (Table 6), which is 27.49% of the total shipment value. However, under scenario 3, the actual loss will be larger. When the shipping prices are consistently less than the marginal costs, producers will give up picking and abandon strawberries in the field. The average marginal cost of harvesting, packing, cooling, and selling strawberries in California is about 50 cents per pound (Daugovish *et al.,* 2011). An industry survey we conducted in 2012-2013 indicates that the average marginal cost in Florida is about 77 cents per pound. Assuming these costs increase by 3% per year over the next five years, the marginal costs will be 58 and 89 cents per pound at the end of the period for California and Florida, respectively. In this case, California strawberry producers would continue to harvest and ship strawberries despite reduced shipment values. However, Florida strawberry producers would stop harvesting when the market price falls below the harvest threshold of 89 cents per pound, because the price is not enough to recover the cost of harvesting, packing, cooling and selling. Thus, the shipment values from the last week of February to the last week of March will become zero; the production season is shortened by five weeks. This will further reduce revenues by 64.63 million dollars in scenario 3. Accounting for this additional loss, the total reduction in the Florida shipment value will amount to 145.29 million dollars, which is about half the value of the current industry. The lost shipment value (minus the cost saving due to reduced harvest and shipment) will translate into an average reduction of $8,923 per acre in net return. As the industry is already struggling to break even (making zero profit) under the current market condition, the extra losses caused by the increased Mexican supply will pose serious challenges to the sustainability and survival of the Florida strawberry industry.

4. Conclusions and discussions

This study aims to shed light on the impact of Mexican competition on the U.S. strawberry industry. The study develops a strawberry market model and examines the effects of the shipments of Mexican strawberries on the prices and shipment values of the U.S. winter strawberries. The estimated price flexibilities suggest that Mexican shipments significantly affect the prices of California and Florida strawberries. In particular, the simulation results indicate that further expansion in Mexican production capacity will cause severe losses to U.S. growers, decreasing the profitability and sustainability of the industry. The empirical methods used in our study could be applied to other produce or to other countries to examine the potential impact of competition and the increasing market shares of competitors on prices and shipment values.

The findings in our study provide a clear indication of the challenges and difficulties the U.S. strawberry industry is facing. There have been heated debates on the trade policy in light of NAFTA. The industry has been exploring options to ensure industry sustainability, including changes in trade policy. The industry's main argument for change is that Mexican production has been ‘unfairly subsidized’ and that the produce industry has been the ‘sacrificial lamb’ in the trade deal.

Given the large losses found in this study, improved production and marketing are necessary for the domestic industry to remain viable under NAFTA. The efforts to reduce costs are critical for the strawberry industry, especially for the Florida industry, to survive. This calls for advancements in production technologies. In particular, introduction of mechanical harvesting could substantially reduce costs and increase the competitiveness of the U.S. industry. It may take time and a large investment to develop a mechanical harvesting system. However, the cost reductions that come with mechanization could effectively neutralize Mexico’s competitive advantage in labor cost, thus creating a level playing field between Mexico and the U.S. The bed and mulch production system adopted in the 1970’s and 1980’s was a major innovation over the last few decades. Mechanical harvesting potentially could be another major event in technological innovation. It could not only reduce cost but also address the serious labor shortage problem in the industry. Besides labor-saving technologies, developing new and superior varieties could also help growers differentiate in the generic commodity market to alleviate the impact of competition. Unlike in the apple market where varieties are usually labeled distinctly with recognizable differences in size, appearance and taste, strawberries are usually not labeled by variety and are generally treated as generic commodity. The U.S. strawberry industry is investing in research and development seeking to differentiate their products from competitors. Florida strawberry industry is taking further measures to limit Mexican access to new varieties Florida is developing. However, successful product differentiation of a generic commodity may require institutional changes to ensure effective coordination within the industry in branding and labeling as well as regulation of quality standards. In summary, the industry may need significant changes in technology, marketing, and industrial organization to effectively compete in the marketplace.

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