Modeling the Interactions of Strawberry Commodity and Labor Markets in the US and Mexico

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Fresh strawberries are an important crop in the U.S. fruit and vegetable industry, with a national farm gate value of $2.35 billion in 2013. Florida is the largest producer of winter strawberries in the U.S., accounting for about 90% of winter strawberry production. The overall economic contribution of the industry to the state economy was estimated at over $1 billion in 2013. In recent years, Mexico, which has the same production window as Florida, has become the major competitor for the U.S. winter strawberries. Imports of fresh strawberries from Mexico were 88 million pounds in 2003, but the volume reached a record of 350 million pounds in 2012, which was approximately four times higher than a decade ago and nearly 2 times higher than Florida production. The rapidly rising imports have led to depressed market prices and caused significant losses for American growers.

Strawberry production is highly labor-intensive. High labor cost is the main source of competitive disadvantage of US strawberries. The minimum wage rate for Florida in 2015 was $8.05 per hour, whereas the rate was only $1.35 per hour for general agricultural labor in Mexican strawberry production area. A Florida strawberry growers survey conducted by the University of Florida in 2013 indicated that labor costs on average accounted for 40% of total revenue. And the cost share of labor will continue to rise because of agricultural labor shortages and the rising wage rate. Because of labor shortages, migrant workers with Mexican background constitute the majority of the labor force in the US. Most of the migrant workers are undocumented. The low-skilled labor supply lowered the US wage in the past, but the available pool of Mexican farmworkers is dwindling. In addition, the current tough immigration policy also separates Mexican labor market from the US labor market, which has had impact on the wage rate on labor markets of both countries.

Given the competition and interactions on both commodity and labor markets between the US and Mexico, this study aims to model the strawberry commodity and labor markets and their interactions. We analyze the effects of Mexican competition, identify factors affecting variables of interest, and predict the dynamics of the industry. Specifically, we will use econometric models to model US-Mexico strawberry trade and agricultural labor wage relationships. This will be the first study to establish a price-equilibrium trade model for strawberries. These models will be estimated and then used to predict future US (Mexico) winter strawberry prices and agricultural wages. Finally, we will conduct an acreage response analysis and determine how the changes in variables of interest will affect strawberry acreage of the two countries.

Theoretical Model

Strawberry Trade Model

A US-Mexico fresh strawberry trade model will be constructed in this section. Following Torok and Huffman (1986), we focus on the US excess strawberry demand and Mexico's excess strawberry supply. The excess demand function has taken into account the US domestic demand and supply, and is represented as

(1) $Q_u = D_u - S_u = Q_u(P_u, W_u, A_u, ZC_u)$,

where D_u and S_u are the US domestic strawberry demand and supply, respectively; Q_u is the US excess or import demand for fresh strawberries; P_u is the real domestic strawberry price; W_u is the real agricultural (farm) wage; A_u is the strawberry acreage; ZC_u is a vector of exogenous variables affecting the US strawberry supply and demand. We use the Florida farm gate price, farm wage, and acreage to stand for P_u W_u,and A_u in eq. 1 given that Florida dominates other states in winter strawberry production and supply.

Similarly, Mexican excess supply function of fresh winter strawberries can be represented as

(2) $Q_m = S_m - D_m = Q_m(P_m, W_m, A_m\ ZC_m)$,

where Q_m is the excess (export) supply of fresh strawberries; P_m is the real domestic Mexican growers' (export) price; W_m is the real domestic Mexican agricultural wage; and $ZC_m$is a vector of exogenous variables affecting Mexico's supply and demand of fresh strawberries. Since the major production area for Mexican winter strawberries is the state of Michoacan, A_m is represented by the strawberry acreage in Michoacán.

The trade equilibrium between the US and Mexico for fresh strawberries is represented by

(3) $Q_u = Q_m = \bar{Q}$,

which means that the US import of fresh strawberries equals Mexican export of fresh strawberries. This is consistent with the reality. The total imports of the US fresh strawberries in 2012 reached 351 million lbs, 350 million lbs of which were imported from Mexico.

Finally, strawberry prices in the two countries are closely linked with each other. Florida strawberry growers tend to supply metropolitan areas on the eastern seaboard and parts of the Midwest. Mexican fresh strawberries enter the U.S. market primarily in California and Texas and typically supply the western half of the U.S. during the winter. Thus shocks from imports may be partially transmitted to Florida growers. We assume the prices to be related stochastically to each other. Therefore, the US-Mexican strawberry price relationship is

(4) $P_u = P_u(P_m, ER)$,

where ER is the exchange rate of dollars to Mexican pesos. Overall, these equations of (1) to (4) form a system that represents the mechanism in which strawberry prices are determined.

Agricultural Wage Model

The US excess demand for agricultural labor is

(5) $L_u = L_u^d - L_u^s = L_u(W_u, FV_u, WC_u, ZL_u)$,

where L_u^d and L_u^s are the US domestic quantities of agricultural labor demand and supply; L_u is the US excess (import) demand for agricultural labor; W_u is the real domestic US (Florida) agricultural wage; FV_u is the real domestic US fruit and vegetable price; WC_u is the real domestic US wage of construction laborers; and ZL_u is a vector of exogenous variables affecting the US domestic demand and supply of agricultural labor. Migrant agricultural labor is employed in commodity-specific activities in winter, in particular, working in fruit and vegetable fields. Therefore, the fruit and vegetable price (FV) is expected to impact labor demand. In addition, immigrant agricultural workers might take jobs in the nonagricultural labor market. The main competing industry is construction, a major alternative employment option for immigrant workers, which attracts a large number of laborers out of agriculture when the US economy is in a good condition. Thus, construction workers' wage rate (WC) is taken into account in the model.

Mexican immigrants constitute a major share of the immigrant agricultural labor force of the United States. According to the National Agricultural Worker Survey, Mexico-born workers represented an estimated 79% of the US farm workforce in 1998-2000. Mexico's excess supply of agricultural labor to the US is derived by the same method as before, and is represented as

(6) $L_m = L_m^d - L_m^s = L_m(W_m, FV_m, WC_m, ZL_m)$,

where $W_m, FV_m,$ and WC_m are Mexican agricultural wage, Mexican fruit and vegetable price, and wage rate of Mexican construction workers, respectively.

The relationship of agricultural wages between the two countries is complicated by the restrictions on legal immigration, illegal immigration, and enforcement efforts by the Border Patrol. The border enforcement is to discourage illegal migrants from entering into the US. In the 1990s, enforcement was strengthened significantly in high traffic areas, especially along the California and Texas borders (Cerrutti and Massey, 2004). The number of hours that Border Patrol officers spent policing the Mexican border rose from 1.8 million in 1977 to 5.1 million in 1997 (Hanson et al., 2002). The budget for border enforcement increased from 399 million dollars in 1994 to 877 million dollars in 1998. As a result, the total illegal alien apprehensions in all southwest sectors increased by 55% during the same period. These enforcement efforts have reduced the supply of immigrant labor from Mexico to the US and could increase the gap of wage rates between the two countries. The US-Mexican agricultural wage relationship is

(7) $W_u = W_u(W_m, ER, BP)$,

where *BP* is the expenditure of the Border Patrol.

Acreage Decision Model

Crop price and yield, which determine growers' return, have been the main variables used in previous analyses to explain acreage response. Likewise, dramatic change in agricultural wage, the major component of production cost, could have significant impacts on return and in turn allocation of farmland. The previous studies have greatly enhanced our understanding of how price and yield affect crop allocation decisions, but none has identified the separate effect of wage despite its potentially significant effect on acreage supply. We follow Chavas and Holt (1990) and propose an acreage response model which decomposes the return impact into separate contributions for price, yield and wage. Chavas and Holt (1990) developed the model based on a utility maximum framework and analyzed growers' acreage decisions under price and yield uncertainties. We extend the model to include an extra component of wage. The resulting acreage response function is

(8) $A_i = A_i(E(P_i), E(Y_i), E(W_i), V(P_i), V(Y_i), CV_i)$, for *i=u (the US) or m (Mexico)*

where A_i is the strawberry acreage in the US or Mexico; $E(P)$ is the expected strawberry price; $E(Y)$ is the expected strawberry yield; $E(W)$ is the expected wage; $V(P)$ is the variance of strawberry price; $V(Y)$ is the variance of strawberry yield; and CV is the covariance of strawberry price and yield. Note that the variance of monthly wage is rather stable over time and therefore is not included.

Data and Empirical Models

Monthly time-series data are used for estimating the strawberry trade and agricultural wage models, while annual data are used to estimate the acreage decision model. The winter growing season Nov-Apr from 1994 to 2013 is covered because this is a unique time period when Florida and Central Mexico are the primary suppliers of fresh strawberries to the US consumers. The starting date is the first winter after the North American Free Trade Agreement (NAFTA) took effect, which eliminated the strawberry tariff.

Strawberry Trade Model

The strawberry trade model can be represented by eqs. (9)-(12). Variables in equations are defined in table 1. The equations are expressed in the log linear form. Eq. (9) is an inverse demand function and models the Florida farm gate price responses to excess demand for winter strawberries in the United States, while eq. (10) is an inverse supply function and models the

Mexican growers' export price response to excess supply of strawberries. The inverse functional form is to facilitate price forecast, used for acreage response function. Since the unit root test shows that the null hypothesis of unit root for real US (Mexican) agricultural wage cannot be rejected, we use the change of (log) wage rate (DW) in eqs. (9) and (10) to address the problem of non-stationary data. The per capita income is expected to be positive, suggesting that higher per capita income will increase strawberry consumption and thus promote trade with Mexico. In addition, the eq. (9) ((10)) links excess demand (excess supply) with strawberry production which is determined by acreage (A) and weather conditions (Tem). Climatic variable (Tem) affects production in the US(Mexico) and in turn influences imports from Mexico (exports to the U.S.). The inclusion of monthly dummies is to capture the feature of seasonality, while TR is an annual trend controlling for population growth. Eq. (12) describes the price relationship between the two countries. Consumer price indexes (CPI_m and CPI_u) are included as a result of the conversion of prices from real to nominal values.

US Excess Demand for Fresh Market Strawberries

(9) $$lnP_u = a_0 + a_1 lnQ_u + a_2 A_u + a_3 DW_u + a_4 lnPCI_u + a_5 Tem_u + a_6 Nov + a_7 Dec + a_8 Jan + a_9 Feb + a_{10} Mar + a_{11} TR + e_1$$

Mexico's Excess Supply of Fresh Market Strawberries

(10) $$lnP_m = b_0 + b_1 lnQ_m + b_2 A_m + b_3 DW_m + b_4 lnPCI_m + b_5 Tem_m + b_6 Nov + b_7 Dec + b_8 Jan + b_9 Feb + b_{10} Mar + b_{11} TR + e_2$$

Strawberry Trade Equilibrium

(11) $$lnQ_u = lnQ_m = \bar{Q}$$

US-Mexico Strawberry Price Relationship

(12) $$lnP_u = c_0 + c_1 lnP_m + c_2 lnER + c_3 lnCPI_m + c_4 lnCPI_u + c_5 Nov + c_6 Dec + c_7 Jan + c_8 Feb + c_9 Mar + e_3$$

Agricultural Wage Model

The agricultural wage model is presented by eqs. (13)-(15). Two main issues need to be addressed in the model. One is that excess supply and demand of agricultural labor are not observable. This endogenous variable is captured by the error term and will be addressed by an instrumental variable estimation method. Exogenous variables (*ZL*) in eqs (13) and (14) include the real expenditure of the Border Patrol and unemployment rate. However, the Augmented Dickey Fuller (ADF) tests show that the two variables are not stationary. To address the issue, we use the changes of expenditure (*DBP*) and unemployment rate (*DUNE*) as explanatory variables in eqs. (13) and (14). In addition, monthly dummies are included to capture the seasonality.

US Farm Wage Determination

(13) $DW_u = d_0 + d_1 lnFV_u + d_2 DBP + d_3 DUNE_u + d_4 DWC_u + d_5 Nov + d_6 Dec + d_7 Jan + d_8 Feb + d_9 Mar + e_4$

Mexico's Farm Wage Determination

(14) $DW_m = f_0 + f_1 lnFV_m + f_2 DBP + f_3 DUNE_m + f_4 DWC_m + f_5 Nov + f_6 Dec + f_7 Jan + f_8 Feb + f_9 Mar + e_5$

US-Mexico Farm Wage Relationship

(15) $DW_u = g_0 + g_1 DW_m + g_2 lnER + g_3 lnCPI_m + g_4 lnCPI_u + g_5 DBP + g_6 Nov + g_7 Dec + g_8 Jan + g_9 Feb + g_{10} Mar + e_6$

Acreage Response Model

Similar to the models developed by Chavas and Holt (1990) and von Massow and Weersink (1993) and more recently by Weersink et al. (2010), the empirical model of eq. (8) is written as

(16) $A_{i,t} = \gamma_{i,0} + \gamma_{i,1} E(P_{i,t}) + \gamma_{i,2} E(Y_{i,t}) + \gamma_{i,3} E(DW_{i,t}) + \gamma_{i,4} V(P_{i,t}) + \gamma_{i,5} V(Y_{i,t}) + \gamma_{i,6} CV_{i,t} + \gamma_{i,7} A_{i,t-1} + \eta_{i,t}$,

for *i=u and m.* The model includes a lagged acreage variable, and a partial adjustment process is implied if $\gamma_{i,7}$ is less than 1. Particular attention is given to the risk factor, which plays an important role in acreage decisions, since strawberry supply is sensitive to weather and price sensitive to supply due to the high perishability of the commodity.

Estimation of the acreage response model requires defining growers' expectations of price, yield, wage, and the variance-covariance matrix of price and yield. Expected monthly strawberry prices can be estimated from eqs. (9)-(12) under the rational expectation hypothesis.

Shonkwiler and Emerson (1982) stated several reasons to support that growers form rational expectations in the context of tomato trade modeling. We predict monthly strawberry prices from eqs. (9)-(12) and take their average as expected yearly price. The variance of price is the variation of expected monthly prices. The expected wage is measured in the same way.

The expected yield and the variance of yield can be estimated with a Just-Post stochastic production function

(17) $Y = f(X, \alpha) + g(X, \beta)\varepsilon$,

where Y denotes random crop yield; X is a vector of factors including climatic variables. $f(\cdot)$ is the mean-yield function (or deterministic component of yield); and $g(x)\varepsilon$ is a composite error term, where $g(\cdot)$ is the yield risk function and ε is a random disturbance, capturing production uncertainty, with mean 0 and variance 1.The JP specification is a widely used framework in agricultural risk modeling since there are no *a priori* restrictions on the risk effect of inputs. The same independent variables can be used for both the mean and variance of yield. In this analysis, three climatic variables are used: (1) monthly average minimum temperature (*Min*), (2) monthly average maximum temperature (*Max*), and (3) monthly precipitation (*Rain*). The mean yield component is specified as

(18) $Y_{i,t} = \alpha_{i,0} + \alpha_{i,1}Min_{i,t} + \alpha_{i,2}Max_{i,t} + \alpha_{i,3}Rain_{i,t} + \epsilon_{i,t}$, for *i=u or m.*

Assume that the variance of yield takes an exponential form. The least square residuals from equation (18), $\tilde{\epsilon}$, are used to estimate the marginal effects of explanatory variables on the variance of yield. The variance component is therefore specified as

(19) $\ln(\tilde{\epsilon}^2) = \beta_{i,0} + \beta_{i,1}Min_{i,t} + \beta_{i,2}Max_{i,t} + \beta_{i,3}Rain_{i,t} + \varepsilon_{i,t}$.

Parameters in eqs (18) and (19) can be estimated using OLS. The expected yield ($E(Y_i)$) is based on the expectation of weather conditions for the upcoming growing season. The expectation for each climatic variable is assumed to be a weighted average of the measures over the last three years with the weights equal to 0.5, 0.33, and 0.17. They are substituted into equations (18) and (19) to generate $E(Y_{i,t})$ and $V(Y_{i,t})$.

The final variable to be specified in (16) is the covariance of price and yield, which cannot be assumed to be independent. We calculate it using the following formula

(20) $CV_{i,t} = \rho\sqrt{V(P_{i,t})V(Y_{i,t})}$

where ρ is the correlation coefficient between price and yield, which is assumed to be constant over the period of study, and the variances of price and yield are calculated as illustrated above.

Results and Discussion

Strawberry Trade Model

The estimation results of the strawberry trade model are presented in table 2. The strawberry price elasticity of US excess demand for winter strawberries is -5, suggesting that the excess demand on a monthly basis is quickly responsive to the price change. The value seems large when compared to price elasticity for winter tomatoes. Torok and Huffman reported a price elasticity of excess demand of about -0.29 for Florida tomatoes based on a monthly analysis, while Shonkwiler and Emerson estimated the price elasticity of demand of about -0.8 using annual observations. The results illustrate that the US strawberry demand is much more sensitive to price change than tomato demand. The elasticity of the US price relative to agricultural wage is of interest in this study. The value is relatively small (0.83) but significant, showing that price is modestly responsive to wage changes. The relatively low value implies that growers can not charge more to compensate the rising wage cost. The reasons behind it are the competing produce from Mexico and the weak negotiating ability of growers. Labor cost is a major component of the variable cost of producing fresh strawberries. The inelastic response of price would squeeze growers' profit and even make growers out of business in the environment of rising wage rate. Table 2 also shows that over the winter months of November to April the US strawberry price exhibits a definite seasonal pattern which monotonically diminishes over the season.

The price elasticity of Mexican excess supply of fresh winter strawberry is 1.16. This relatively high price elasticity is consistent with expectation because Mexican strawberry growers are flexible in supplying strawberries to the US. They can reduce domestic consumption and allocate more strawberries to the US when the export price is high. When the price is low, they can also turn to the processing or domestic fresh markets. The elasticity of price relative to wage in Mexico is comparable to the US, but the effect of wage on the price is not significant. The per capita income elasticity of price is 0.98. Mexican consumers with high income are competing with the US consumers on strawberries, resulting in more and more strawberries being consumed domestically. It also requires a higher export price bid to induce export. Finally, there is not a strong link between the Florida (U.S.) and Mexican fresh winter strawberry prices. The coefficients for P_m and *ER* are 0.07 and -0.24, respectively, and are insignificant. This is as expected since the geographic area supplied by Mexican and Florida fresh strawberries is generally different.

Agricultural Wage Model

The estimation results of the agricultural wage model are presented in table 3. The elasticity of Florida agricultural wage relative to fruit and vegetable price index is positive but insignificant. The elasticity of wage relative to the unemployment rate is negative and significant, suggesting that more labor will be available in a weak employment situation and cause agricultural wage to decline. As expected, agricultural wage will increase with the US wage of construction laborers. As an alternative employment opportunity for the US agricultural labor, construction employment and wage are a main driving force for the agricultural wage.

Similarly, the effect of Mexican fruit and vegetable price index on Mexican agricultural wage is not significant, though its sign is positive and consistent with the expectation. Contrary to the US agricultural wage equation, the estimated coefficient of *BP* in the Mexican agricultural wage is significant. Sain et al. (1983) reported a strong positive relationship between apprehensions and the activity of the Border Patrol. Thus, other things equal, the expenditures on Border Patrol activity will reduce the probability of successful illegal immigration, increase Mexican domestic labor supply, and fall wage. Monthly seasonal dummy variables are included in two wage equations to take account of monthly shifts. However, estimates for these variables are not significant implying that wages have no seasonal pattern. The results in table 3 also show that there is a statistically strong relationship between the Florida and Mexican agricultural wage rates.

Acreage Response Model

The estimated parameters of the expected yield equation (18) are listed in Table 4. The Chi-square statistics are statistically significant implying that the climatic variables are jointly able to explain the expected yield values. The most important weather variable for Florida strawberry yield is precipitation. A 1-inch increase in monthly precipitation is estimated to decrease total yield by approximately 1,100 lbs. This is different from California, where the effect of precipitation is positive (Lobell et al., 2007). Other climatic variables are not statistically significant for Florida strawberry yield. With regard to Mexican strawberry yield, the effect of precipitation is insignificant, which is likely associated with the fact that production in central Mexico is nearly all under high tunnel. High tunnel can also fight the low temperature well and reduce yield losses as a result of a breakout of freeze event. The coefficient estimate of minimum temperature is negative and significant, suggesting that lower temperature will inversely increase yield. The estimated parameters for the yield variance equation (19) are given in Table 5. For whether the US or Mexican yield variance, the F-values are statistically significant indicating that the climatic variables are jointly able to explain the variance of yield, but the explanatory power is not high. The weather variable increasing yield variance is average maximum temperature. The relationship is as expected because high temperatures above 30 °C are known to reduce fruit size (Wang and Lin, 2006), fruit weight (Kumakura and Shishido, 1994), fruit quality and overall plant growth (Hellman and Travis, 1988).

The results of the acreage response equation (17) are listed in Table 6. The overall fit of the resulting model is very good for the US acreage response, with the adjusted R^2 value of 0.89. However, the fit is not good for the Mexican acreage response, because the adjusted R^2 is only 0.21. The low explanatory power for Mexico is a result of some key factors being omitted, such as policy intervene. Mexican strawberry acreage is substantially affected by Mexican government policy. For example, the Secretary of Agriculture, Livestock, Rural Development, Fishing and Food of Mexico (SAGARPA) motivated berry planting and production capacity through subsidizing high tunnel structure. .

The results show that expected wage growth has a negative effect on the US strawberry area. This is consistent with the expectation. A strawberry grower survey conducted in 2013 has identified labor shortage and an escalating labor cost as one of the top three main challenges to

Florida strawberry industry. Growers have reported abandoning a significant amount of fruits in the field due to the high labor cost. Without enough labor to harvest their crops, growers would have to either downsize their operations or stop farming altogether. This estimation result confirms the hypothesis. Other variables, such as expected price, yield and variance-covariance matrix of them are generally not important. Lagged planted area is also statistically significant. The coefficient is greater than 1 indicating a quick expansion process. As for Mexican acreage response, all variables with the exception of expected yield have no statistically significant effects on planted area. Increases in expected yield will increase growers' acreage. The relative importance in expected yield on the acreage response is consistent with observations in other strawberry production areas of Mexico. For example, growers in Guanajuato, Mexico have allocated their strawberry farmland to other crops along with the declining yield of strawberries.

Conclusions

Fresh strawberries are a very important crop in the U.S. produce industry. However, it is striking that there is little economic research on the industry. In particular, Mexican competition has posed significant challenges to the U.S. winter strawberry industry, and escalating labor costs are eroding the industry's competitiveness, which calls for an impact analysis and forecast of acreage changes. In this study, we propose three models: strawberry trade model, agricultural wage model, and acreage response model. The econometric analysis examines factors affecting the fresh winter strawberry trade, wage level and acreage change for the two countries. The results show that the US rising labor cost is pushing the US strawberry price up. However, the price cannot fully offset wage growth, which results in the declining return. On the other hand, the US strawberry demand will decrease as a result of the increased price, and the share of Florida strawberries will be shrinking. The combined outcome would erode Florida growers profit and force them to switch to other crops. The results from the acreage response model have confirmed that growers will reduce strawberry acreage when the wage is expected to rise. These empirical results have important policy implications for policy makers.

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Table 1. Definitions of variables used in Equations (9) to (15)

Name	Definition
P_u	Real average Central Florida farm gate prices for fresh winter strawberries ($/cwt). Source: the U.S. Department of Agricultural, Agricultural Marketing Service
Q_u, Q_m	Monthly imported strawberries to the US from Mexico (cwt). Source: World Trade Atlas
DW_u	The change of real average monthly (log) farm wage in Florida ($/hour). Source: the U.S. Department of Agricultural, National Agricultural Statistics Service
PCI_u	Real monthly per capita income in the US ($). Source: Federal Reserve Bank of St. Louis.
Tem_u	Average monthly minimum temperature at Dover, Florida (°C). Source: Florida Automated Weather Station
P_m	Real Mexican growers' (export) price (peso/cwt). Source: World Trade Atlas
DW_m	The change of real average monthly (log) farm wage in Mexico (peso/day). Source: Secretaria de Trabajo Y Prevision Social
PCI_m	Real monthly per capita income in Mexico (peso). Source: World Bank.
Tem_m	Average monthly minimum temperature at Zamora, Mexico (°C). Source: Comisión Nacional del Agua
$Jan, \ldots, Mar$	Monthly dummy variables
TR	Annual trend
ER	Market exchange rate of dollars to pesos (peso/$). Source: International Monetary Fund.
CPI_m	Consumer price index of Mexico. Source: International Monetary Fund
CPI_u	Consumer price index of the US. Source: International Monetary Fund
FV_u	Real fruit and vegetable price index in the US. Source: Federal Reserve Bank of St. Louis
FV_m	Real fruit and vegetable price index in Mexico. Source: Instituto Nacional de Estadistica Geografia
DBP	The change of real expenditure on the US Border Patrol (million dollars). Source: US

	Customs and Border Protection
$DUNE_u$	The change of unemployment rate in the US. Source: International Monetary Fund
$DUNE_m$	The change of unemployment rate in Mexico. Source: International Monetary Fund
DWC_u	The change of real wage rate of construction laborers of the US ($/hour). Source: Bureau of Labor Statistics
DWC_u	The change of real wage rate of construction laborers of Mexico (peso/day). Source: Secretaria de Trabajo Y Prevision Social

Table 2. Coefficient estimates with standard errors for an econometric model of the U.S.-Mexican strawberry trade

US Excess Demand				Mexico Excess Supply				Price Relationship			
		Estimates	SE			Estimates	SE			Estimates	SE
Cons.	a_0	11.84	9.63	*Cons.*	b_0	-7.16**	3.59	*Cons.*	c_0	9.44	0.94
lnQ_u	a_1	-0.19**	0.09	lnQ_m	b_1	0.86***	0.17	lnP_m	c_1	0.07	0.09
lnA_u	a_2	-0.30	0.26	lnA_m	b_2	-0.59***	0.20	$lnER$	c_2	-0.24	0.23
DW_u	a_3	0.83*	0.44	DW_m	b_3	0.77	1.03	$lnCPI_m$	c_3	0.45**	0.19
$lnPCI_u$	a_4	-0.19	0.76	$lnPCI_m$	b_4	0.98***	0.33	$lnCPI_u$	c_4	-1.48***	0.29
$lnTem_u$	a_5	-0.02***	0.01	$lnTem_m$	b_5	-0.06***	0.02	Nov	c_5	1.11***	0.08
Nov	a_6	0.68***	0.22	Nov	b_6	2.40***	0.38	Dec	c_6	0.94***	0.07
Dec	a_7	0.54***	0.16	Dec	b_7	1.69***	0.30	Jan	c_7	0.61***	0.08
Jan	a_8	0.35***	0.10	Jan	b_8	0.81***	0.17	Feb	c_8	0.44***	0.08
Feb	a_9	0.26***	0.08	Feb	b_9	0.69***	0.15	Mar	c_9	0.12**	0.06
Mar	a_{10}	0.07	0.07	Mar	b_{10}	0.21*	0.11				
TR	a_{11}	0.02	0.02	TR	b_{11}	-0.15***	0.03				

Note: please refer to Table 1 for variable descriptions. *, **, and *** indicate significance at 0.1, 0.05, and 0.01 levels.

Table 3. Coefficient estimates with standard errors for an econometric model of the U.S.-Mexico Agricultural Labor Markets

		US Farm Wage				Mexico Farm Wage				Wage Relationship	
		Estimates	SE			Estimates	SE			Estimates	SE
Cons.	d_0	-0.14	0.19	*Cons.*	f_0	0.03	0.02	*Cons.*	g_0	0.83	0.77
$lnFV_u$	d_1	0.14	0.19	$lnFV_m$	f_1	0.07	0.08	DW_m	g_1	0.32***	0.08
DBP	d_2	-0.04	0.00	DBP	f_2	-0.59**	0.00	$lnER$	g_2	0.08*	0.05
$DUNE_u$	d_3	-0.01**	0.01	$DUNE_u$	f_3	0.01**	0.01	$lnCPI_u$	g_3	-0.20	0.22
DWC_u	d_4	0.86**	0.37	DWC_u	f_4	0.66***	0.05	$lnCPI_m$	g_4	-0.14**	0.06
Nov	d_5	0.01	0.02	Nov	f_5	0.00	0.01	DBP	g_5	0.10	0.07
Dec	d_6	0.00	0.02	Dec	f_6	-0.01	0.01	Nov	g_6	0.00	0.02
Jan	d_7	0.00	0.02	Jan	f_7	-0.01	0.01	Dec	g_7	0.00	0.02
Feb	d_8	0.00	0.02	Feb	f_8	0.00	0.01	Jan	g_8	-0.01	0.02
Mar	d_9	0.00	0.02	Mar	f_9	0.00	0.01	Feb	g_9	0.00	0.01
								Mar	g_{10}	0.00	0.01

Note: please refer to Table 1 for variable descriptions. *, **, and *** indicate significance at 0.1, 0.05, and 0.01 levels.

Table 4. Estimated parameters of expected yield equation

		US Expected Yield				Mexico Expected Yield	
		Estimates	SE			Estimates	SE
Cons.	$\alpha_{u,0}$	693.24	268.45	*Cons.*	$\alpha_{m,0}$	1008.10	529.09
Min_u	$\alpha_{u,1}$	3.16	9.52	Min_m	$\alpha_{m,1}$	-38.20**	14.82
Max_u	$\alpha_{u,2}$	-17.42	11.18	Max_m	$\alpha_{m,2}$	-15.04	14.93
$Rain_u$	$\alpha_{u,3}$	-10.95**	4.78	$Rain_m$	$\alpha_{m,3}$	10.31	51.98

Note: *, **, and *** indicate significance at 0.1, 0.05, and 0.01 levels.

Table 5. Estimated parameters of yield variance equation

		US Yield Variance				Mexico Yield Variance	
		Estimates	SE			Estimates	SE
Cons.	$\beta_{u,0}$	-23.03	19.66	*Cons.*	$\beta_{m,0}$	-2.12	18.42
Min_u	$\beta_{u,1}$	-0.24	0.70	Min_m	$\beta_{m,1}$	-0.06	0.52
Max_u	$\beta_{u,2}$	1.24**	0.62	Max_m	$\beta_{m,2}$	0.32**	0.16
$Rain_u$	$\beta_{u,3}$	0.05	0.35	$Rain_m$	$\beta_{m,3}$	-0.07	1.81

Note: *, **, and *** indicate significance at 0.1, 0.05, and 0.01 levels.

Table 6. Coefficient estimates with standard errors for the U.S. and Mexican Acreage Response Equations

		US Acreage Response				Mexico Acreage Response	
		Estimates	SE			Estimates	SE
Cons.	$\gamma_{u,0}$	238.05	5067.30	*Cons.*	$\gamma_{m,0}$	4873.06	3576.46
$E(P_u)$	$\gamma_{u,1}$	-7.30	18.69	$E(P_m)$	$\gamma_{m,1}$	-1.70	2.12
$E(Y_u)$	$\gamma_{u,2}$	-1.23	18.25	$E(Y_m)$	$\gamma_{m,2}$	1.47*	0.76
$E(DW_u)$	$\gamma_{u,3}$	-839.92**	419.22	$E(DW_m)$	$\gamma_{m,3}$	-49.99	95.31
$V(P_u)$	$\gamma_{u,4}$	25.43	22.05	$V(P_m)$	$\gamma_{m,4}$	-10.66	10.23
$V(Y_u)$	$\gamma_{u,5}$	1.48	2.56	$V(Y_m)$	$\gamma_{m,5}$	-3.10	4.70
$CV(P_u, Y_u)$	$\gamma_{u,6}$	31.14	28.33	$CV(P_m, Y_m)$	$\gamma_{m,6}$	41.00	31.10
$A_{u,t-1}$	$\gamma_{u,7}$	1.17	0.25	$A_{m,t-1}$	$\gamma_{m,7}$	0.28	-0.36

Note: *, **, and *** indicate significance at 0.1, 0.05, and 0.01 levels.