Structure of the Fresh Onion Market in the Spring Season: A Focus on Texas and Its Competition

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A structural model of the spring onion economy is developed to analyze forces affecting the onion-producing sector in Texas. Spring onion prices in Texas are influenced by own shipments, shipments from storage stocks, and variety. Texas's decline in market share is largely the result of expanded late summer (storage) onion production. A decline in the U.S. real tariff and a weakening of the real exchange rate (pesos/$) encouraged onion imports from Mexico during the study period. However, this impact was offset by the imposition of quality standards in 1980 and the growth in domestic late summer onion production. Study period results did not support the recent contention of Texas producers that onion imports from Mexico are unfavorably affecting prices received.

Key words: international trade, interregional competition, onions.

Texas is a leading supplier of fresh onions during the spring season with a national market share of nearly 40%. Onions are the most valuable vegetable crop produced by Texas farmers with sales comprising nearly a fifth of the total vegetable revenues in the state. Most of the spring onion production in the United States and Texas (95%) is sold fresh, thus the focus on this market.

Considerable debate and speculation exist regarding the effect of various economic forces and competing production regions on the spring onion market. This debate is partially the result of a declining market share held by Texas spring onion producers and the recent discussion regarding the Bush Administration's proposed free trade agreement with Mexico. The shipping season in Texas commences in mid-March and extends into June. During the first half of the shipment period, storage onions from late summer producing regions and im-

ports of new-crop onions from Mexico are important. Domestic new-crop producers constitute the primary competitors in May and June. In this article attention is given to evaluating the effect of imported Mexican onions on the price of the spring crop in Texas. Recently, some producer groups in south Texas have viewed the imports as competition. Shippers hold that imports from Mexico and Texas shipments overlap very little and the imports complement the Texas product by preparing the consumer for the new-crop onion (Dinker).

To offer insight into these concerns, a structural model of the spring onion economy is developed which centers on factors affecting spring onion production and prices in Texas, imports of onions from Mexico, and onion production and prices in Mexico. Factors hypothesized to affect these variables are late summer onion production, exchange rates, onion exports from the United States, incomes of the Mexican and United States populations, tariffs, and the variety of onions marketed by Texas producers. The estimated equations are used to evaluate the role of competing supplies on production and price of Texas onions with particular attention given to the links between

onion sectors in Mexico and the United States during the spring season.

Literature Review

Suits and Koizumi focused on the dynamics of the onion economy through the development of a three-equation econometric model of the U.S. market. They studied the systematic oscillations of onion price and output over the 1929 through 1952 period, and they observed this cyclical phenomenon to be a textbook example of a cobweb system.

As well, Jesse estimated seasonal onion supply and demand models for the United States. The purpose was to assess possible differences in the structure of onion demand and supply relationships that resulted from cessation in onion futures trading.

Shafer and Connolly independently carried out studies examining factors influencing spring onion prices in Texas. Shafer estimated seasonal average spring onion price as a function of Texas production, 1 January onion stocks, and per capita disposable income. The estimated price flexibility was -1.34, while the cross flexibility with respect to 1 January stocks was estimated to be -1.43. The sign on the income coefficient was negative but not statistically different from zero. Connolly found increases in U.S. income had no statistically significant influence on onion price, and a 1% increase in production lowered spring onion price by 1.53%—a finding that parallels that of Shafer.

Other studies with a related focus are those which examine competition between Mexico and U.S. producers of winter vegetables. In 1979, Zepp and Simmons argued Mexican growers had a comparative advantage in production of fresh winter vegetables as compared to Florida producers. In view of the increasing market share held by Mexican producers in the late 1960s and early 1970s, Florida growers sought protection with proposed nontariff trade barriers and by filing an antidumping petition with the Federal Trade Commission in 1978. Both attempts were unsuccessful. Despite these failures, Florida producers have generally retained or increased their share of the U.S. winter vegetable market. Bredahl et al. maintained that technical change in Florida rejuvenated that industry. This conclusion was supported by analyzing yield data and the relative price of labor in Florida and Mexico. More recently, Taylor and Wilkowske rigorously examined productivity growth in the two regions and drew similar conclusions to those reached by Bredahl et al.

Sanderson held that Mexico does not represent a significant threat to the U.S. fresh vegetable industry. It is argued that much of Mexico's increasing role in the winter market can be attributed to increasing per capita consumption of fresh vegetables in the United States and not to absolute declines in U.S. production. Further, except for Florida, no region in the United States has a winter climate which permits competing vegetable production; too, because Mexico generally serves western U.S. markets, it does not represent significant competition for Florida. In addition, Sanderson asserted that the U.S. tariff and the inefficient marketing system in Mexico, in particular the transportation system, make Mexico a marginal producer, a producer which must continually monitor U.S. markets to find periods when it is cost effective to export. Sanderson indicated that Mexican imports have a significant effect on U.S. price when there is a short U.S. crop and prices are abnormally high, usually the result of a freeze or natural disaster in the United States.

Schuh argued that exchange rates have the potential to impact U.S.–Mexican vegetable trade. Mares observed an increase in contraband exports to the United States since 1982, the period when the peso was allowed to float relative to the dollar. The attraction of earning dollars by exporting vegetables placed a severe strain on Mexico's system of vegetable production and export. To offset the attraction of contraband, producer unions in Mexico made room for additional exports even at the expense of weakening the U.S. market (Mares). The analysis presented here offers insights on the role of tariffs and exchange rates in U.S.–Mexican onion trade in the spring season and, in particular, identifies the impact of this trade on Texas onion price.

Model Development

Background

The production and consumption of onions in the United States have tended upward over the past two decades. However, this growth
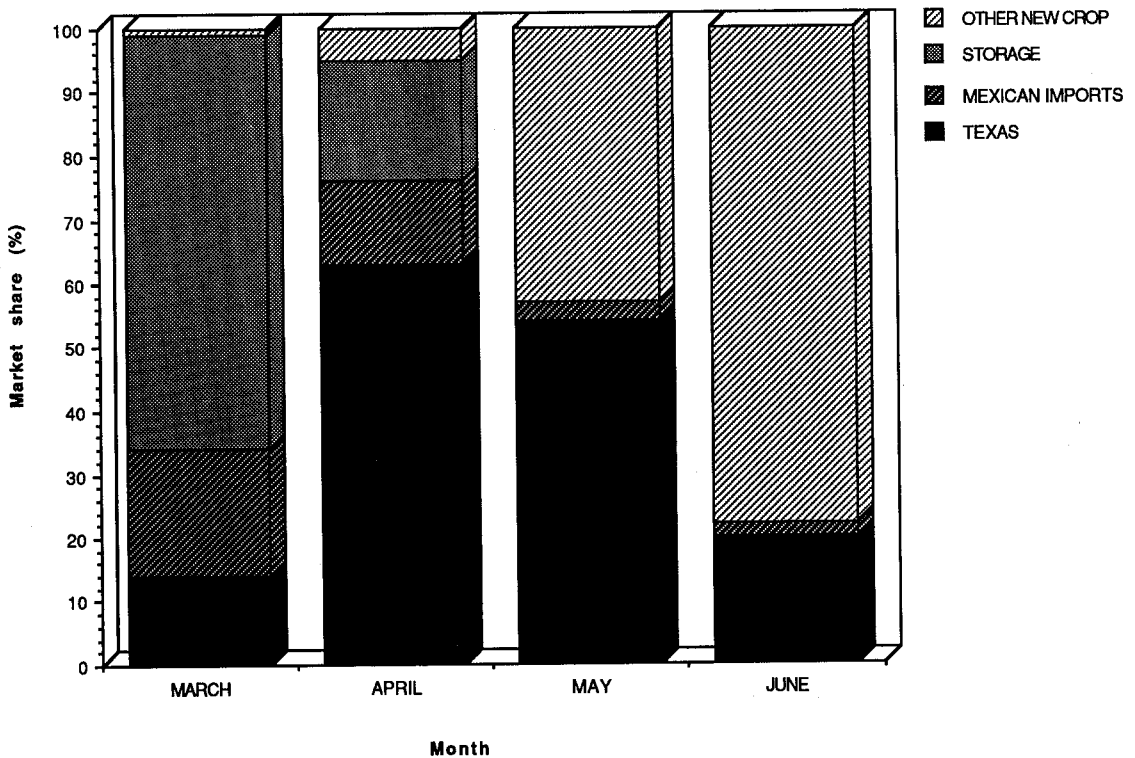
Figure 1.   Monthly market share in spring onion market (1976–86)

has not been enjoyed by spring onion farmers in Texas. Over the past decade, their shipments have declined while output from competitors has increased, thus a decline in national market share (Fuller, Goodwin, and Shafer).

Competition for the spring onion producer in Texas comes from several sources. Early in Texas's window (March, April), late summer producers (Colorado, Idaho, New York, Oregon, and Washington) ship storage stocks while new-crop onions are imported from Mexico (figure 1). In March, about two-thirds of all fresh onion shipments to U.S. consumers originate from storage stocks, slightly over 20% are imported from Mexico, and the remainder is supplied by Texas. Market shares are reversed in April—about two-thirds of all shipments are from Texas and 20% from storage stocks. Remaining supplies originate in Mexico (10%) and other new-crop producers (5%). In May and June, new-crop production in Arizona, California, and New Mexico provides competition for Texas onions. The market shares held by these producers average about

45% and 80%, respectively, while respective shares average about 52% and 18% for Texas producers. The monthly share for Mexican producers during May and June is generally less than 3% (Fuller, Goodwin, and Shafer).

Additional forces which conceptually act on the spring onion market include the quantity of onions exported from the United States, variety of onions marketed by spring producers in Texas, and per capita income. Exports of fresh onions during the spring season have accounted for .5% to 2.6% of total domestic shipments in the United States over the past decade. Texas produces three varieties of onions for which separate price series are available: a white-skinned onion, often the most valuable, and two yellow-skinned varieties, Grano and Granex.

The planting of spring-harvested onions in Texas commences in September and extends into November. Number of acres planted by Texas producers in the fall is largely dependent on expected price which is conditioned by prices and profitability of the previous harvest. This situation gives rise to a production pat-

tern characterized by alternative years of high and low shipments, an outcome which had been observed earlier by Suits and Koizumi. In addition, Texas producers appear to be keenly aware of the competition offered by storage onions in the early portion of their marketing window and, accordingly, adjust plantings so as not to oversupply this window.

Since 1961, vegetable producer unions in Mexico have controlled the production and export of vegetables. These unions collaborate with the Mexican government in development of an annual plan of production and export, their programas siembra-exportacion. The principal producer union, the National Union of Vegetable Producers [Union Nacional de Productores de Hortalizas (UNPH)] is comprised of 13 regional unions and 35 local associations of growers covering most of Mexico. The UNPH allocates acreage and export permits to regional affiliates which subsequently distribute allotments to producers. By specifying planting dates and allocating acreage among regions, the UNPH attempts to stabilize export shipments (Sanderson). In addition, Mexican producer groups have established quality requirements to further control the volume of produce entering the U.S. market (Mares).

Selected vegetable distributors in the United States, typically located in Texas and Arizona border communities, act as consignment brokers or contract purchasers of Mexican vegetables. Mexican producers send their products to distributors on consignment in amounts requested by the U.S. distributors. Some contracts are simple agreements to purchase based on quality, delivery dates, sizes, and other criteria, while other contracts specify production methods and extend credit to the Mexican producers (Sanderson).

Historically, Mexico has exported 9% to 15% of its annual onion production, the majority going to the United States. Onions entering the United States during the spring season are produced in the Cuernavaca area in the State of Morelos and in the Tampico area in the state of Veracruz. Onion-producing technology in both the U.S. and Mexico is similar, with the Mexican producer making increased use of labor for some activities.[1]

Section 980.117 of U.S. onion import regulations specifies that imported onions which are competitive with domestic production meet the same rules as applied to domestic onions. Since the South Texas Onion Order (959) includes provisions relating to grade, size, maturity, and quality, it follows that onion imports from Mexico must also meet these standards [U.S. Department of Agriculture (USDA 1981)]. The import regulations are effective from March through May and were initiated in September 1979. In addition, a tariff of $1.75/cwt. is levied on all onions entering from Mexico during the spring season, a levy which has been in place for over a decade (USDA 1976–85d).

Structural Relationships

The set of relationships in figure 2 serves as a basis for specifying a simultaneous equation model of the spring onion sector. The structural model includes six behavioral equations and an identity. The model is representative of the classical two-county trade paradigm. The specified model includes each country's respective excess demand and supply functions. The specified equations incorporate the traditional demand and supply shifters as well as variables dealing with exchange rates, the real tariff, and a U.S. policy variable which places standards on the imported Mexican onion.

The model includes: (1) a price-dependent equation for Texas spring onions ($TXPR$), (2) a quantity-dependent shipment equation for onions supplied by Texas producers in the spring season (TXS), (3) a quantity-dependent equation relating demand for Mexican onions by U.S. consumers in the spring season (IM), (4) a price-dependent demand equation for Mexico's own production ($MXPR$), (5) a quantity-dependent supply equation for onions produced in Mexico (MXP), (6) a quantity-dependent excess supply equation for onions annually supplied by Mexico ($MXEXP$), and (7) an identity which equates the quantity of Mexican-produced onions available for domestic consumption and export in other than the spring season ($MXPIM$) to the difference between annual Mexican production (MXP)

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[1] Importers of Mexican onions indicate that onion-production technology in Mexico and the United States is similar. However, generally more labor is used by Mexican producers. For example, Mexican producers employ labor to cover export-destined bulbs

with soil once they have been uncovered by wind or rain. This task keeps the bulb from turning green, a characteristic not desired by the consumer. In contrast, Texas producers generally find it unprofitable to employ labor to accomplish this task.
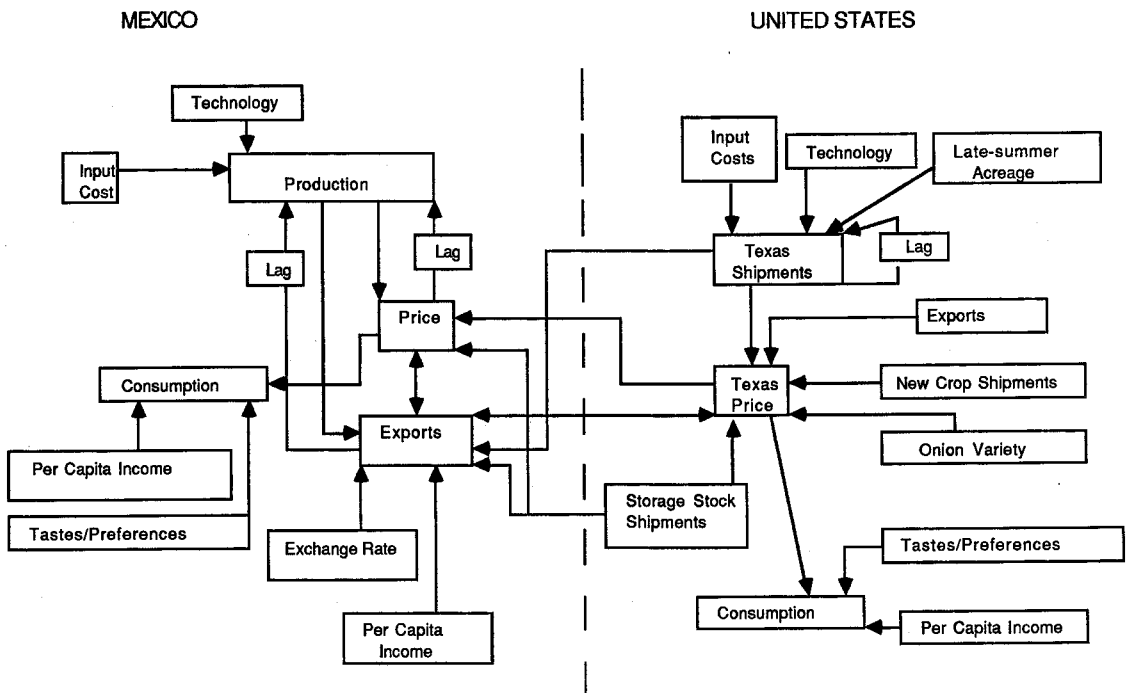
Figure 2.   Structure of spring onion relationship in Mexico and in the United States

and exports to the United States in the spring (*IM*).

The first equation is a derived demand for Texas spring onions. Theory suggests the producer onion price in Texas (*TXPR*) is determined by the quantity of own-onion shipments by Texas producers in the spring (*TXS*), competing shipments from storage stocks in March and April (*SKA*), competing shipments by other new-crop competitors in the spring (*NC*), as well as imports from Mexico in the spring (*IM*). Shipments from stocks (*SKA*) and shipments by other new-crop competitors (*NC*) are viewed as predetermined in the spring; however, in a larger system they would be considered endogenous. Texas own-onion shipments and shipments from competing regions are expected to have a negative influence on Texas price (*TXPR*). Because the export of U.S. onions during the spring season (*EX*) is small, it is included as an exogenous variable. Exports are expected to have a positive effect on Texas price (*TXPR*). Based on the work by Shafer and by Connolly, it is hypothesized that income (*PDI*) is negatively related to onion price in Texas. Both researchers, however, found the relationship to be statistically insignificant. Also included as explanatory variables are the

white (O_1), Granex (O_2), and Grano (O_3) onion varieties marketed by Texas producers. Varieties are included as 0–1 variables:

$$(1) \quad TXPR = f(TXS, SKA, NC, IM, EX, \\ PDI, O_1, O_2, O_3).$$

The price vector (*TXPR*) includes the seasonal average price for each onion variety (O_1, O_2, O_3). Because of data limitations, information on shipments by variety was not available.[2] Consequently, the shipments variable (*TXS*) is an aggregate of all varieties.

The second equation, the Texas onion shipment equation, specifies the quantity of spring onions shipped by Texas producers during the spring season to be a function of Texas average onion price during the previous season (*LAP*), acreage planted to storage or late summer onions (*ALS*), and a production cost index representative of the planting period (*LPC*). There was no indication that competing enterprises

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[2] The South Texas Onion Committee was able to identify acreages planted to white, Grano, and Granex onions in the 1987/88 and 1988/89 seasons. Based on yield and acreage data, an effort was made to estimate shipments by variety over the 1976–85 study period. However, when estimated shipments by variety were substituted for total shipments, the model not only no longer satisfied stability conditions but also yielded perverse results.

or land constraints influence the shipment of Texas onions in the spring:

(2) $TXS = f(LAP, ALS, LPC)$.

The lagged price variable (LAP) is included to capture the cobweb phenomenon; the coefficient on this variable is expected to have a positive sign. The storage onion is harvested in late summer and fall and is stored for subsequent shipment through the following winter and spring. As such, this onion provides competition for the spring-harvested product in Texas. Consequently, when Texas spring onion producers commence planting in September, they consider the anticipated size of the storage crop against which they will compete in the subsequent spring. To obtain insight on the anticipated size of the late summer or storage crop, they identify acreage planted to late summer onions. If planted acreage is large, Texas producers are inclined to plant less and vice versa. The ALS variable is a measure of this potential competition. A negative sign is expected on the ALS variable and on the production cost index (LPC). The production cost index measures costs during the Texas spring onion producers' planting period in September through November. Increasing input costs (LPC) should shift the supply relationship to the left, thus the negative relationship between production costs and Texas onion price.

The quantity of Mexican onions demanded by U.S. consumers during the spring season (IM) is specified as a function of Texas onion price $(TXPR)$, the U.S.–Mexico border price of the imported onion net the real tariff $(MXTPR)$, per capita disposable income (PDI) of U.S. consumers, the real tariff (RTF), and the previous year's onion imports during the spring season (LIM):

(3) $IM = f(TXPR, MXTPR, PDI, RTF, LIM)$.

The Texas spring onion and the storage onion are substitutes for the imported onion, and because their prices are correlated, the selected Texas onion price variable $(TXPR)$ may be viewed as a proxy for both onion types. Texas price $(TXPR)$ is expected to have a positive impact on the quantity of Mexican onions demanded (IM) by U.S. consumers. Imports from Mexico are not in direct competition with other new-crop onion (NC) shipments since imports generally precede these shipments. The price of the imported Mexican onion net the

real tariff $(MXTPR)$ and the tariff (RTF) should have negative influences on imports (IM). The lagged import variable (LIM) captures the influence of contractual arrangements on the U.S.–Mexico onion trade.[3]

The next relationship is a derived demand relationship for onions in Mexico. Theory suggests that the annual onion price in Mexico $(MXPR)$ [equation (4)] is a function of annual onion production in Mexico which is either consumed in Mexico or available for export in other than the spring season $(MXPIM)$, onion production which is exported by Mexico to the United States in the spring (IM), and real per capita income in Mexico as measured in pesos $(MXPDI)$. In contrast to domestic price and production data which are available on a monthly or seasonal basis, the data from Mexico are only available on an annual basis:

(4) $MXPR = f(MXPIM, IM, MXPDI)$.

Mexico's onion price is hypothesized to be negatively related to $MXPIM$ but thought to be positively related to Mexico's exports to the United States in the spring (IM) and to real per capita income as measured in pesos $(MXPDI)$.

The annual supply of onions in Mexico [equation (5)] is specified as a function of the previous year's annual price $(LMXPR)$, lagged annual exports to the United States $(LMXEXP)$, and a Mexican production cost index $(LMXPC)$ applicable during the planting period:

(5) $MXP = f(LMXPR, LMXEXP, LMXPC)$.

Due to the cobweb phenomenon, production in the current period is hypothesized to be positively related to price in the previous period, thus a positive sign is expected on the $LMXPR$ variable. The previous year's exports $(LMXEXP)$ are believed to have a positive impact on production, while the effect of cost $(LMXPC)$ on annual production in Mexico, in accord with economic theory, is thought to be negative.

The quantity of onions annually supplied to the United States by Mexico $(MXEXP)$ is specified as a function of Mexico's onion production (MXP), the price of Texas spring onions

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[3] Based on statistical choice procedures, Thursby and Thursby show that import demand specifications which include lagged dependent variables (dynamic behavioral specifications) generally perform best.

(*TXPR*), Mexico's onion exports to the United States in the prior year (*LMXEXP*), the real tariff levied by the United States on onion imports from Mexico (*RTF*), the real pesos/dollar exchange rate during Mexico's onion planting season (*LAREX*), and a binary policy variable (*Q*) dealing with the imposition of quality standards on Mexican onion imports in 1980:

(6) $MXEXP = f(MXP, TXPR, LMXEXP,$
$RTF, LAREX, Q).$

Theory suggests that the quantity of onions annually supplied by Mexico to the United States is positively related to Mexico's own production (*MXP*), the price of Texas onions in the spring (*TXPR*), and lagged Mexican exports to the United States (*LMXEXP*). The nominal tariff on onion imports was fixed at $1.75/cwt. throughout the 1976–85 study period. Because price levels increased dramatically during this era, the effect of the tariff may have been lessened; thus, the real tariff (*RTF*) was included in the specified equation. A negative sign is expected on the *RTF* variable. The policy variable (*Q*) reflects the potential impact associated with the requirement that imported onions meet the grade, size, maturity, and quality standards specified for the Texas onion by the South Texas Onion Order. This policy was initiated in 1980 and is expected to have reduced the import of onions during the spring season.

Because of a highly organized system of vegetable production and exportation in Mexico and because of the lag associated with the onion production process, Sanderson suggests that the relevant exchange rate is not associated with the current export period but with the earlier planting season. Consider that Mexican producer unions decide on acreage to be planted for the spring export crop during late summer of the previous year, i.e., Mexico's onion exports in the spring are the result of acreage planted in the late summer of the previous year. At planting time, Mexican producers develop expectations about the future exchange rate based on the observed real pesos/dollar exchange rate. If producers view the exchange rate favorably at planting, we assume they are inclined to plant increased acreage for the upcoming export season, thus a positive relationship between the exchange rate at planting and the export level in the following spring season. Since most of Mexico's onion exports to the United States are planted in late sum-

mer, the exchange rate variable (*LAREX*) in the excess supply equation is the real pesos/dollar rate associated with the summer quarter of the previous year.[4]

The final equation, an identity, equates the quantity of Mexican-produced onions available for consumption in Mexico and available for export in other than the spring season (*MXPIM*) to the difference between annual Mexican production (*MXP*) and exports to the United States in the spring (*IM*). Thus,

(7) $MXPIM = MXP - IM.$

Data and Statistical Procedures

The study period extends over the decade 1976 to 1985 and is limited to this era because of the unavailability of data on onion prices and production in Mexico in later years. Most data from Mexico are available only as annual observations and are collected from publications of the USDA, the International Monetary Fund, the Secretaria de Agricultura y Recursos Hidraulicos, and S. A. Marsa.

The seasonal average price of the three spring-harvested onion varieties (O_1, O_2, O_3) are included. The data correspond to annual observations. There exist 10 annual observations for each onion variety. The data are stacked by variety, hence 30 observations are used in the analysis. The price series differ by variety. All other variables are the same for each variety in a particular year.

Although the price data series for the various onion varieties show similar year-to-year movements, the white-skinned variety (O_1) is typically the most valuable. Further, the price of onions in Mexico tends to parallel Texas prices, but at levels which are often about half of the Texas price (table 1). This fact implies the operation of similar price-making forces in the two markets.

During the 1976–85 period, spring onion shipments from competing regions tended upward, in particular, new-crop (*NC*) and storage stock shipments (*SKA*). Texas spring onion shipments are characterized by consecutive

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[4] The real exchange rate is calculated as illustrated by Schuh, namely the product of two terms: the nominal exchange rate in terms of pesos per dollar and the ratio of the U.S. wholesale price index to the Mexican wholesale price index. The nominal exchange rate (pesos per dollar) represents the average of buying and selling rates reported by main commercial banks to the Bank of Mexico.

Table 1. Variable Identification, Description, and Descriptive Statistics

Variable Identification	Description	Mean	Standard Deviation	Minimum	Maximum
TXPR	Texas spring onion average price (all onion varieties), 1976–85 ($/cwt.)	8.80	3.10	4.56	16.41
	Texas white onion	10.06	3.31	6.42	16.41
	Texas Granex onion	8.45	3.38	4.56	15.12
	Texas Grano onion	7.89	1.96	6.04	12.49
TXS	Texas spring onion shipments, 1976–85 (1,000 cwts.)	3,329.6	688.0	2,510.0	4,875.0
SKA	Storage onion shipments in March and April, 1976–85 (1,000 cwts.)	1,442.6	556.4	82.0	2,259.0
NC	Other new-crop onion shipments in spring, 1976–85 (1,000 cwts.)	2,891.4	691.5	2,107.0	3,852.0
IM	U.S. onion imports from Mexico in March–June, 1976–85 (1,000 cwts.)	708.6	194.2	398.0	1,019.0
LIM	Lagged U.S. onion imports from Mexico in March–June, 1975–84 (1,000 cwts.)	662.9	202.6	398.0	1,019.0
EX	U.S. exports of onions in spring, 1976–85 (1,000 cwts.)	111.7	66.5	37.0	208.0
PDI	U.S. per capita disposable income, 1976–85 ($)	6,900.8	1,226.2	5,696.5	8,670.3
O_2	0–1 variable, Texas Granex onion	—	—	—	—
O_3	0–1 variable, Texas Grano onion	—	—	—	—
Q	0–1 variable, quality requirements established for onion imports in 1980 (1976–79 = 1), (1980–85 = 0)	—	—	—	—
LAP	Lagged average price for all Texas spring onions, 1975–84 ($/cwt.)	8.84	2.3	4.79	11.98
ALS	Acres of late summer onions, 1975–84	54,022.0	5,138.8	45,710.0	64,530.0
LPC	Lagged Texas onion production cost index, 1975–84 (1975 = 100)	255.9	36.1	194.0	290.0
LMXPC	Lagged Mexico onion production cost index, 1975–84 (1975 = 100)	143.2	28.1	104.8	199.4
MXPR	Mexico's average annual onion prices, 1976–85 ($/cwt.)	4.72	1.94	2.83	9.99
MXP	Mexico's annual onion production, 1976–85 (1,000 cwts.)	8,138.6	1,128.0	6,372.0	9,415.0
RTF	Real onion tariff, 1976–85 ($/cwt.)	1.22	0.25	0.99	1.67
MXTPR	Border price of imported Mexican onion net the real tariff ($/cwt.)	12.70	4.05	8.79	22.41
LAREX	Real exchange rate in Mexico's onion planting season, pesos/dollar, 1975–84 (1975 = 100)	14.33	2.64	11.35	19.60
MXEXP	Mexico's annual onion exports to the U.S., 1976–85 (1,000 cwts.)	1,067.0	241.4	710.0	1,431.0
MXPDI	Mexico's per capital disposable income, pesos, 1976–85	20,664.9	1,438.8	18,476.0	22,991.0
LMXPR	One-year lag in *MXPR*	4.82	1.88	2.83	9.99
LMXEXP	One-year lag in *MXEXP*	662.9	202.61	398.0	1,019.0
MXPIM	*MXP − IM*	7,430.0	2,266.2	5,974.0	8,710.0

Sources: *TXPR* and *LAP*, USDA 1976–85b; *TXS, SKA, NC, IM, EX,* and *MXEXP*, USDA 1976–85c; *PDI*, U.S. Department of Commerce; *ALS*, USDA 1976–85e; *LPC*, USDA 1976–85a; *MXPR* and *MXP*, Secretaria de Agricultura y Recursos Hidraulicos; *RTF* and *MXTPR*, USDA 1976–85d; *LAREX* and *MXPDI*, International Monetary Fund; *LMXPC*, Marsa.

years of high and low shipments, a production pattern typical of a cobweb system. Imports of onions from Mexico during the spring season are relatively small as compared to that supplied by other sources.

The structural model consists of seven endogenous variables, three lagged endogenous variables, and 15 exogenous variables. Based on rank and order conditions, the model is overidentified. Thus, the technique of two- and three-stage least squares is appropriate to estimate the structural parameters. As well, the presence of lagged endogenous variables permits the calculation of interim and total multipliers from the specified structural relationships.

Empirical Results

Structural Equations

The estimated structural equations are shown in table 2. The system of equations is, econometrically speaking, simultaneous although several equations are not functions of right-hand-side endogenous variables. Estimates of the structural parameters were obtained using two-stage least squares. Attempts to use three-stage least squares lead to irreconcilable singularity problems in the estimated variance-covariance matrix of the disturbance terms. The t-statistics associated with the estimated coefficients appear in parentheses.

Although conventional tests of significance are not strictly applicable, it is judged that 21 of the 28 coefficients are significantly different from zero. The significance level chosen for this study is the .10 level. In all cases, the statistically significant coefficients have the anticipated signs. Values of the goodness-of-fit measures (R^2) range from .49 [equation (2), TXS] to .96 [equation (6), $MXEXP$]. Based on Durbin Watson and/or Durbin-h statistics, serial correlation problems are not evident.

Results show spring onion shipments in Texas (TXS) and shipments from storage stocks in March and April (SKA) are significant and, as suggested by theory, have a negative effect on Texas price [equation (1)]. Onion shipments by other new-crop producers (NC) and onion exports (EX) have the expected sign but neither is statistically significant. Onion imports from Mexico (IM) do not have a significant effect on the Texas spring onion price

($TXPR$).[5] This result is not supportive of the argument forwarded by some Texas producers that imports are unfavorably affecting their spring price. This outcome supports Sanderson's view that Mexico is a marginal provider of produce to the United States and only on occasion offers competition to U.S. producers. Granex (O_2) and Grano (O_3) onion varieties are lower-valued than the white variety (O_1), the reference category; however, only the price of the Grano variety is significantly lower than the white variety. Real per capita disposable income (PDI) has a negative and statistically significant impact on spring onion price, a similar finding to those of Shafer and Connolly.

The quantity of onions shipped by Texas producers (TXS) in the spring season [equation (2)] is positively related to the previous year's average price for all onions (LAP), an outcome supporting Suits and Koizumi's earlier observation that onions behave as a cobweb system. Acreage planted to late summer onions (storage) (ALS) in the spring has a negative and significant affect on acreage planted by Texas producers in the fall.

The quantity of Mexican onions demanded by U.S. consumers in the spring (IM) is negatively related to the price of these onions ($MXTPR$), the real tariff, and lagged imports [equation (3)]. Per capita disposable income (PDI) of U.S. consumers and the price of Texas spring onions ($TXPR$) have a positive impact on the import of Mexican onions.

Per capita disposable income of the Mexican population ($MXPDI$) has a statistically significant and positive influence on the price of that country's onion ($MXPR$) [equation (4)]; this outcome contrasts with the above finding regarding the effect of U.S. income on Texas onion price. As expected, Mexican price is negatively related to own production that is not exported ($MXPIM$) and positively influenced by the quantity of Mexican onions demanded by U.S. consumers in the spring (IM).

Exports to the United States in the previous year ($LMXEXP$) and Mexican price lagged one period ($LMXPR$) have a positive effect on the quantity of onions produced by Mexican farmers in the current year (MXP) [equation (5)]. The sign and significance of the $LMXPR$ variable implies the cobweb system may best de-

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[5] Several different specifications of the Texas demand equation were estimated and, in all cases, onion imports from Mexico (IM) were not statistically significant.

Table 2. Estimated Structural Equations for Spring Onion Model

(1)   Texas demand:

$$TXPR = 65.9520^* - .00626TXS^* - .00759SKA^* - .00336NC + .00179IM + .00532EX$$
$$\quad\;\, (3.731) \quad\quad (4.094) \quad\quad (3.157) \quad\quad (1.496) \quad\quad (.408) \quad\quad (.494)$$
$$- .00235PDI^* - 1.6144O_2 - 2.1678O_3{}^*$$
$$\quad\; (1.974) \quad\quad (1.522) \quad\quad (2.043)$$

$R^2 = .5904$ DW = 2.193

(2)   Texas shipment:

$$TXS = 7,486.104^* + 123.249LAP^* - .0715ALS^* - 8.008LPC$$
$$\quad\;\;\, (2.501) \quad\quad (2.971) \quad\quad (2.990) \quad\quad (.714)$$

$R^2 = .4948$ DW = 2.523

(3)   U.S. demand for Mexican onions:

$$IM = 1,582.627^* + 18.351TXPR - 23.559MXTPR^* + .3740PDI^* - 2,454.831RTF^* - .4865LIM$$
$$\quad\;\, (3.354) \quad\quad (1.436) \quad\quad (2.035) \quad\quad (4.160) \quad\quad (4.761) \quad\quad (1.739)$$

$R^2 = .6282$ Durbin-$h = .191$

(4)   Mexico demand:

$$MXPR = -6.9276^* - .00187MXPIM^* + .0025IM^* + .001149MXPDI^*$$
$$\quad\quad (4.416) \quad\quad (13.155) \quad\quad (3.650) \quad\quad (14.421)$$

$R^2 = .9209$ DW = 1.889

(5)   Mexico supply:

$$MXP = 8,182.208^* + 382.143LMXPR^* + 1.4933LMXEXP^* - 23.7358LMXPC^*$$
$$\quad\;\;\, (7.200) \quad\quad (7.019) \quad\quad (2.817) \quad\quad (5.330)$$

$R^2 = .8121$ DW = 1.869

(6)   Mexico supply of onions to the United States:

$$MXEXP = -357.6287 + .1629MXP^* + 18.2352TXPR^* + .0818LMXEXP - 699.584RTF^*$$
$$\quad\quad\; (.984) \quad\quad (8.114) \quad\quad (3.407) \quad\quad (1.458) \quad\quad (4.165)$$
$$+ 34.2674LAREX^* + 599.665Q^*$$
$$\quad\; (4.863) \quad\quad (9.144)$$

$R^2 = .9586$ Durbin-$h = .812$

Note: t-values are in parentheses. Asterisk indicates statistical significance at the .10 level. The R^2 value is computed using the actual right-hand-side Y after obtaining the 2SLS estimates.

scribe production and prices in Mexico. As suggested by theory, increased production costs ($LMXPC$) unfavorably impact production.

As expected, the annual quantity of onions supplied to the United States by Mexico ($MXEXP$) is positively related to Mexican production (MXP), price of the spring onion in Texas ($TXPR$), onion exports to the United States by Mexico in the previous year ($LMXEXP$), and the real exchange rate (pesos/dollar) at onion planting ($LAREX$). The value of the real tariff (RTF) has a negative effect on quantity of onions annually supplied to the United States. Similarly, the binary policy variable (Q) shows the imposition of onion grade, size, maturity, and quality standards by the United States in 1980 unfavorably impacted the import of Mexican onions. Thus, the weakening of the peso ($LAREX$) and the declining value of the tariff favorably impacted exports during the study period, whereas the imposition of quality standards in 1980 was an effective nontariff barrier.

Multipliers

To obtain the net short-run and long-run impacts of changes in the exogenous variables on the endogenous variables, impact and total multipliers are calculated. Total multipliers refer to the accumulated changes in endogenous variables due to unit changes in exogenous variables. Because of emphasis on long-run impacts, selected flexibilities and elasticities calculated from the total multipliers are presented in the next section.

Interim multipliers offer insight into the adjustment process over time. Most of the adjustment processes are oscillatory. Importantly, this adjustment pattern is consistent with the stability conditions of the model. Based on eigenvalues of the matrix of reduced-form co-

efficients associated with lagged endogenous variables, the model is stable. That is, the dominant root is less than one in modulus. In fact, the dominant root is negative, implying dampening oscillatory movements.

Implications

The estimated structural model and associated multipliers offer strong evidence that the late summer or storage onion has a significant effect on the spring onion economy in Texas. The structural model shows acreage planted to late summer onions (*ALS*) has a negative and significant impact on Texas spring onion shipments (*TXS*). Similarly, onion shipments from storage (*SKA*) have a negative and significant effect on Texas price (*TXPR*). In the long run, a 1% increase in shipments from storage (*SKA*) lowers Texas price (*TXPR*) 1.27%.

During the 1976–85 period, acreage planted to late summer onions increased from 45,710 to 64,530 acres, an annual increase of about 4%. In an effort to keep from oversupplying the spring window, Texas producers reduce their shipments; based on the estimated long-run elasticity, a 1% increase in acreage planted to late summer onions (*ALS*) would lead to a 1.16% reduction in Texas shipments (*TXS*). Assuming all other forces were constant over the 1976–85 period, this increase in planted acreage would have reduced Texas shipments about 50%, a reduction which closely parallels the actual decline in Texas production from 4,875 thousand cwts. in 1976 to 2,568 thousand cwts. in 1985.

The analysis shows international trade of fresh dry onions during the spring to have little effect on the spring onion producer in Texas. The export variable (*EX*) is not significant in the Texas price equation and the export elasticity with respect to price is estimated to be only .07. Further, there is no statistical evidence that import of onions from Mexico during the spring (*IM*) has an unfavorable effect on the Texas price. The import variable (*IM*) in the Texas price equation is not significant, an outcome which seems intuitive in view of Mexico's modest market share (figure 1). A modest market share in combination with efforts by the Union Nacional de Productores de Hortalizas to stabilize vegetable exports through allocation of acreage and export per-

mits has apparently yielded few price disruptions in the United States onion market.

Onion imports from Mexico in the spring are affected by Texas price (*TXPR*). When Texas price is high, imports are increased. *Ceteris paribus,* a 1% increase in Texas spring onion price (*TXPR*) increases Mexican imports (*IM*) .68%.[6] This finding seems to support Sanderson's view that Mexico becomes an increasingly competitive supplier when U.S. production is short and price is relatively high. Sanderson believes tariffs and high transportation costs often make Mexico a marginal supplier to the U.S. vegetable market.

Several governmental policies affected U.S.–Mexican onion trade during the 1976–85 study period. The structural model shows that the imposition of a nontariff policy, the requirement that onion imports meet grade, size, maturity, and quality standards (*Q* variable) specified by the South Texas Onion Order, reduced Mexico's exports to the United States by 599 thousand cwts. over the sample period. In addition, the quantity of onions imported by the United States in the spring (*IM*) is sensitive to U.S. tariff policy. This result is not surprising since the nominal tariff ($1.75/cwt.) is about 30% of Mexico's average annual onion price (*MXPR*). Assuming all other variables are constant, a 1% decrease in the real tariff increases Mexican imports by 2.90%; during the period 1976–85, the real tariff declined about 40%. Further, the Mexican government's decision in 1982 to float the peso favorably influenced the supply of onions made available to the United States (*MXEXP*). Since 1982, the real pesos/dollar exchange rate increased about 25%, and based on the calculated exchange rate elasticity, the supply of onions made available to the United States, *ceteris paribus,* would have increased about 14%.

Concluding Comments

Onions are the most valuable vegetable crop produced in Texas. Historically Texas pro-

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[6] Elasticities and flexibilities can be calculated from the reduced-form equations when both variables are endogenous. This calculation is carried out by multiplying 1% of each of the mean values of the exogenous variables by the associated reduced-form coefficients in the appropriate equations and then summing the resulting values. The summed values are then included in a ratio which is multiplied by a ratio of their means for purposes of estimating the elasticities/flexibilities.

ducers have supplied nearly 40% of the fresh onions consumed in the United States during the spring; however, in recent years, Texas's market share has declined. To learn more about the principal forces affecting the price and production of the spring crop in Texas, a simultaneous equation model was specified and estimated. Most of the estimated coefficients were judged statistically significant and, with one exception, their coefficients had the anticipated sign. Further, impact, interim, and total multipliers, expressed in flexibilities and elasticities, were reasonable in terms of sign and magnitude.

Texas's declining market share is partially the result of the increasing production of late-summer storage onions. The storage onion is harvested in the late summer and fall and held for subsequent shipment through the winter and spring. As such, this onion provides competition for the spring-harvested product in Texas. So as not to oversupply the spring window, Texas producers give close attention to the anticipated size of the storage crop when planting their spring harvested crop in September and October. During the sample period, acreage planted to storage onions increased at an annual rate of 4%. In reaction, for each 1% increase in late summer onion acreage, Texas producers reduced their shipments by 1.16%. As such, Texas shipments were reduced about 50% over the 1976–85 period, thus the declining market share.

This study found no statistical evidence to support Texas producers' recent concern that spring season imports of Mexican onions were having an unfavorable impact on Texas spring onion price. The analysis suggests that the United States tends to import from Mexico when the Texas price is high, i.e., a 1% increase in Texas price (*TXPR*) is associated with a .68% increase in Mexican imports. This supports Sanderson's view that Mexico becomes a competitive supplier only when U.S. production is short and prices are high. Finally, it seems the modest market share held by Mexico over the sample period and its producer union's efforts to stabilize exports to the United States by acreage and export permits have generated few price disruptions in the domestic onion market during the sample period.

In addition, several policy variables seemed to have affected U.S.–Mexican onion trade during the sample period. The analysis shows that a decline in the real tariff (*RTF*) over the

study period encouraged imports from Mexico as did the devaluation of the peso, especially after the peso was allowed to float relative to the dollar in 1982. The increase in the real pesos/dollar exchange rate at planting (*LAR-EX*) increased the supply of Mexican onions to the United States by about 14%. Offsetting these effects was the imposition of quality standards on Mexican onion imports in 1980, a nontariff barrier. Over the sample period, this policy reduced Mexico's onion exports to the United States by an estimated 599,000 cwts.

Additional data beyond the study period (1976–85) are needed to more completely investigate the recent concern of Texas producers that onion imports from Mexico are unfavorably impacting their price. Since 1985, the most recent year of available Mexican data, onion imports from Mexico have increased. In particular, average import levels since 1985 are about 34% higher than the sample period. However, data beyond 1985 presently are not available. Nevertheless, this structural analysis offers insight into the economic forces affecting the Texas fresh onion market in the spring.

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