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Weekly Price-Shipment Demand Relationships for South Texas Onions

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ABSTRACT

This paper presents estimates of the inverse-demand relationship between the price and quantity demanded for onions supplied from South Texas. The study is based on data from 1990-2001. Weekly onion price movements are negatively related to quantities shipped from South Texas as well as from competing regions. The regression shipment coefficients quantify the price impact per truckload shipped from specified regions, while the associated price flexibility estimates quantify price impacts in percentage terms. Weekly onion prices trend down from week to week within the average season, and are positively correlated with the previous weekís price.

RESUMEN

Este artículo presenta las estimaciones de la relación de demanda-inversa entre el precio y la cantidad demandada para las cebollas producidas en el sur de Texas. El estudio está basado en datos de 1990-2001. Las fluctuaciones semanales del precio de las cebollas están relacionadas negativamente a las cantidades embarcadas desde el sur de Texas así como desde las regiones competidoras. Los coeficientes de regresión de los envíos cuantifican el impacto en el precio por cargamento enviado desde regiones específicas, mientras que las estimaciones de la flexibilidad del precio cuantifican los impactos del precio en términos de porcentaje. Los precios semanales de la cebolla tendieron a la baja de semana a semana durante la estación regular, y estuvieron correlacionados positivamente con el precio de la cebolla durante la semana anterior.

Additional Index Words: demand, marketing, price flexibility, regression

Onions are an important irrigated crop in South Texas. According to USDA-NASS (2002), spring onions claim 22% of the total fresh vegetable value of production in Texas, by far the largest share of any vegetable crop.

South Texas has historically been an early domestic supplier of dry onions to the U.S. fresh market. USDA-AMS shipping data between 1990-2001 show that an average of eight percent of the Texas crop is marketed during March, 55% is shipped in April, and the balance is in May/June. During the March Texas shipping season, summer storage onions from Colorado and the Pacific Northwest supply the majority of the dry onion market with Mexican imports also accounting for more than one third of the shipments (Table 1). Texas' share increases to 47% of the market in April while Mexican imports and storage stocks still account for a 39% market share. In May and early June, 60% of the market is supplied by California, Arizona, and New Mexico, with Texas accounting for 28% (Table 1).

Good policy and management decisions within the South Texas industry are dependent on current information to quantify the price impact of increased shipments from within or outside the South Texas region. The purpose of this research is to learn more about the forces that shape Texas onion prices during the Texas marketing window. An inverse demand model is estimated in order to learn more about the role of these various forces during the South Texas market window.

The familiar downward sloping demand relationship embodies the expectation that the quantity of a good demanded by the market increases (or decreases) with lower (or higher) prices. The size of such shifts depends on the slope of the demand relationship, which is an empirical question to be evaluated by regression analysis. Previous demand studies of Texas onions include Shafer (1972) and Fuller et al. (1991, 1992, 1996). In the most recent study of U.S. onions, Malaga et al. (2001) reported income and own price elasticities of demand estimates of, respectively, 0.36 and -0.20. These results mean that a one percent increase in onion price will decrease the quantity of onions demanded by U.S. consumers by 0.2%, while a 1% increase in U.S. consumer income is associated with a 0.36% increase in quantity of onions demanded.

This study focuses on the ìinverse demandî where South Texas onion price is specified as a function of quantity shipped and other economic variables. Besides gaining structural information about the demand for onions, this research provides for calculation of the price flexibility, which shows the percent change in the price of a good for a one percent change in the quantity demanded. Price flexibility estimates can be used to predict the impact of increased/decreased shipments on prices, and are therefore useful for policy analysts and industry planner/regulators such as the South Texas Onion Committee. To gain insight into the high intra-seasonal variability of onion prices, this study examined weekly price and shipment information during the South Texas marketing period for the years 1990 to 2001.

METHODS

Model Specification

To analyze the factors that impact price movement for South Texas onions, the following model was specified:

$$P_t = f\,(Q_{Texas,t},\ Q_{storage,t},\ Q_{newcrop,t},\ Q_{Mexico,t},\ INC_t,\ P_{t-1},\ WK_t) \qquad (1)$$

where:

P_t is weekly real (i.e., inflation adjusted) price per bag of South Texas onions;
$Q_{Texas,t}$ is weekly shipments of South Texas onions;
$Q_{storage,t}$ is weekly shipments of summer storage onions from the northwestern U.S.;
$Q_{newcrop,t}$ is weekly shipments of new crop onions from other U.S. states;
$Q_{Mexico,t}$ is weekly imports of Mexican onions;
INC_t is real income;
P_{t-1} is lagged weekly real price of South Texas onions;
WK_t is the week of the South Texas shipping season.

Testable hypotheses. The variable $Q_{Texas,t}$ is shipments of South Texas onions during the current week of the shipping season, and is hypothesized to fall with rising Texas onion price (i.e., onions have a downward sloping demand curve). Likewise, the onion shipment variables $Q_{storage,t}$, $Q_{newcrop,t}$, and $Q_{Mexico,t}$ are assumed to capture the negative influence of competing regions on onion price movement during the current week of the South Texas shipping season. The variable INC_t is a standard determinant in demand models. Economic theory and intuition allow for the possibility of either positive or negative impact of rising income, INC_t, on inverse demand for onions. For example, rising consumer incomes could involve substitution away from consuming fresh onions (although there is no clear intuition why this would be the case, as there is, say, for switching from compact cars to sport utility vehicles after an increase in income). Evidence from a study of U.S. onion prices indicated a positive relationship between income and onion demand (Malaga et al., 2001).

The lagged (one week) price variable P_{t-1} is included as a determinant of the current week price expectations within the industry. If prices tend to move in the same direction across several weeks, then the lagged dependent variable should be positively correlated with current period prices. If, however, there is considerable reversal of price trends from week to week, the correlation could be zero or negative. The variable WK_t is included to estimate the direction of any significant seasonal trend in prices, P_t. For example, a negative coefficient on WK_t would probably result if higher early season prices declined in the mid/late shipping season.

The model in Equation 1 represents a recursive model of the price structure for spring onions (Tomek and Robinson, 1990). Current production is the primary force determining current price, but the former is itself determined by lagged prices and exogenous factors involved in the planting decision. The advantages of recursive models are that the parameters are identifiable and the method of ordinary least squares may be used to estimate parameters.

Table 1. Market Share for Spring Onions (source USDA-AMS)

		Other			
	Texas	Storage	NewCrop	Mexico	TOTAL
March	9%	54%	2%	36%	100%
April	47%	17%	15%	22%	100%
May+	28%	6%	60%	6%	100%

Data Development

Shipment Data. Weekly shipment data for South Texas onions were obtained from the South Texas Onion Committee for 1990 through 2001 shipping seasons. To predict the inverse demand for South Texas onions, weekly time periods were selected from each year during those weeks when onions were shipped from South Texas. This period normally runs ten to thirteen weeks from mid-March to early June. Onion shipments are officially measured in 22.7 kg (50 lb) sacks or equivalents. For this study, the onion shipment data were converted into 18,160 kg (40,000 lb) units, i.e., the average truckload size of an onion shipment. Thus, the regression model shipment parameter estimates will show the per truckload influence of shipments on weekly onion prices.

Price data. Corresponding weekly revenue information was used to calculate weekly average prices per unit by dividing the weekly revenue by the weekly shipment. Weekly prices for competing regions and Mexico imports were collected from USDA-AMS (http://www.ams.usda.gov). Price data were deflated using the weekly Consumer Price Index (Bureau of Labor Statistics, http://www.commerce.gov) to account for general inflation effects. Therefore the prices used for this study reflected real (vs. nominal) prices.

Other data. Monthly median income data were obtained from U.S. Bureau of Labor Statistics and deflated using a monthly Consumer Price Index to obtain monthly real income.

Statistical Procedures

Data summarization. The data set was developed in MS Excel. Standard spreadsheet statistical functions were used to estimate the sample mean, standard deviation, minimum value, and maximum value of each variable. The coefficient of variation was calculated for each variable by taking the ratio of the sample standard deviation to the sample mean.

Regression estimation. Based on the general model specification in Equation 1, the following inverse demand regression was estimated using ordinary least squares (hereafter referred to as OLS):

$$P_t = a + a_1 Q_{Texas,t} + a_2 Q_{storage,t} + a_3 Q_{newcrop,t} + a_4 Q_{Mexico,t} + a_5 INC_t + a_6 P_{t-1} + a_7 WK_t + e_t \, . \qquad (2)$$

To restate the testable hypotheses above in terms of Equation 2, we expect negative coefficient estimates on a_1 through a_4. The sign of a_5 could be positive or negative, as described previously in the discussion of INC_t. The signs of a_6 and a_7 also have no prior hypotheses imposed from economic theory, but experience suggests that they will be, respectively, positive (i.e., interweekly price trends) and negative (i.e., falling prices through the season). The error term a_t is assumed to be distributed normally with a zero mean and constant variance.

Regression diagnostic procedures. Serial correlation and heteroskedasticity in the model error terms (both violations of basic OLS model assumptions) and multicollinearity were evaluated using standard test procedures (White et al., 1990; Pindyck and Rubinfeld, 1991). When heteroskedastic errors were found, the model results were interpreted using heteroskedastic consistent test statistics for the OLS coefficients (White, 1980).

Price flexibility calculation. The price flexibility for each shipping region was calculated based on the regression parameter estimates using the standard formula:

$$f_{P_i} = \frac{\partial P_i}{\partial Q_i} \times \frac{\overline{Q}_i}{\overline{P}_i} \qquad (3)$$

where $\overline{Q}_i$ and $\overline{P}_i$ are the mean quantity and mean price, obtained from summary statistics.

RESULTS

Onion Summary Statistics. The descriptive statistics (Table 2) show that the nominal (i.e., non-inflation adjusted) average annual price of South Texas onions historically varies with a standard deviation of \$4.49 around a mean price of \$8.59 per 22.7 kg (50 lb) bag. This implies that if an observer was randomly sampling onion prices between 1990 and 2001 (or presumably in the future), the majority of prices observed would fall between \$8.59 +/- \$4.49 per bag (assuming a normal distribution for onion prices). Given the typical break- even of between \$6 and \$7 per bag (Robinson, 2002), this historic price variation reflects a significant price risk to onion producers. This result is also reflected in the coefficient of variation of 52% for nominal onion prices (Table 2). The minimum values for $Q_{storage,t}$ and $Q_{newcrop,t}$ show that during the South Texas onion shipping season, there are periods when no storage onions or no new spring onions from other states were shipped (i.e., min = 0). The coefficient of variation estimates for the shipping variables are all very large, indicating considerable variability in onion shipments (either from production risk or supply responses, or both).

Onion Regression Results. The regression model in Equation 2 performed fairly well in explaining the variation in weekly onion prices (Table 3). The F-statistic for the overall model is highly significant, indicating goodness of fit. The Adjusted R^2 of the estimation is 0.78, which means that the chosen independent variables explain 78% of the variation in onion prices as modeled by Equation 2. Based on the Durbin-H test statistic, we failed to reject the null hypothesis, at the 5% level of significance, that no serial correlation is present (Pindyck and Rubenfeld, 1991). The Breusch-Pagen test results for heteroskedasticity indicated that the assumptions of ordinary least squares is violated by the presence of nonrandomly distributed error terms (Table 3).

Table 3, Column 1 presents ordinary least squares (OLS) regression estimates of the parameters in Equation (2). Given the adequate sample size (n=155), these estimates are assumed to be distributed approximately normal (a necessary requirement for OLS regression) despite the heteroskedasticity indicated above. The signs of the variable coefficients are all in accordance with *a priori* expectations, and all but Q_{Mexico} and INC_t are significant at the 5% level. The coefficient on Q_{Mexico} is only significant at the 15% level, which means that we can reject the hypothesis of a zero coefficient on Q_{Mexico} only 85% of the time. The magnitudes of the onion shipment variable coefficients are all fairly small, but this is merely due to the units of measure (truckloads) in relation to variations in the dependent variable (real price per bag). Table 3, Column 2 shows the calculated price flexibility of each shipment variable coefficient, all of which are in line with prior experience.

Table 3, Column 3 shows the OLS t-statistics associated with the coefficient estimates in Column 1. Because of the heteroskedasticity, the OLS t- statistics are not reliable to test the significance of the coefficient estimates. Therefore the model hypothesis testing is made using the White Heteroskedastic Consistent (WHC) based t-statistics in Table 3, Column 4. These results indicate that all of the model parameter estimates were significantly different from zero at the 5% level, with the exception of Q_{Mexico} and INC_t. The coefficient on Q_{Mexico} is still only significant at the 15% level.

Examination of correlation coefficients between independent variables and variance proportions factors associated with combinations of independent variable combinations (not shown) revealed no problem collinearity (Belsley, Kuh, and Welch, 1980).

DISCUSSION

The variable coefficients in Table 3 show the dollar per bag change in price predicted by a single unit increase in the independent variable (all other things constant). Throughout this section, the dollar amounts represent inflation-adjusted values, which are smaller than nominal values by several percentage points.

In terms of magnitude, the most important explanatory variable in predicting current weekly onion price is lagged price, P_{t-1}. The coefficient estimate shows that, in inflation adjusted terms, a \$1 per bag change (positive or negative) in last weekís onion price is associated with, respectively, a \$0.74/bag change in current week onion price in the same direction. This reflects a scenario that rising or falling onion

Table 2. Descriptive statistics (n=156 observations).

	P_{t-1}	$Q_{Texas,t}$	$Q_{storage,t}$	$Q_{newcrop,t}$	$Q_{Mexico,t}$	INC^{t}
Mean	$8.59	512.5769	402.2115	507.2115	336.4936	15880.39
Std dev	$4.49	401.5314	423.895	548.1058	267.1337	969.1601
Max	$25.91	1370	1539	1785	979	17552.53
Min	$3.49	2	0	0	3	14600.49
C.V.	52%	78%	105%	108%	79%	6%

Table 3. Regression results for inverse demand model (n=155 obs.[z]).

Variable	OLS Coef. Est.	Price Flexibility	OLS Est. t-value	WHC[y] t-value
$Q_{Texas,t}$	-0.00105	-0.0939	-2.562	-2.839
			(P>0.01042)	(P>0.00435)
$Q_{storage,t}$	-00.0015	-0.1053	-2.315	-1.849
			(P>0.02060)	(P>0.06447)
$Q_{newcrop,t}$	-0.00040	-0.0354	-0.094	-0.998
			(P>0.34523)	(P>0.31806)
$Q_{Mexico,t}$	-0.00108	-0.0634	-1.429	-1.457
			(P>0.15307)	(P>0.14507)
INC_t	-0.00021	—	-1.219	-1.137
			(P>0.22292)	(P>0.25574)
P_{t-1}	0.74245	—	14.369	8.473
			(P>0.0000)	(P>0.0000)
WK_t	-0.20374	—	-2.814	-2.119
			(P>0.00489)	(P>0.03408)
Constant	8.01392	—	2.865	2.202
			(P>0.00417)	(P>0.02767)
R^2=0.79	AdjR^2=0.78	Overall F test: F(7,147) = 73.30 (P>0.00000)		

Breusch-Pagen test of H_o: no heteroskedasticity B-P=104.7 ~ X^2 w/ 7df

Reject at 10% level of significance. Implication: Use WHC t-statistics above.

[z] *One endpoint observation was excluded due to inclusion of lagged dependent variable.*

[y] *WHC is t-value based on Whiteís Heteroskedastic Consistent Covariance estimation approach (White, 1980).*

price trends will persist, but moderate, across multiple weeks of a typical shipping season.

WK_t is a seasonal trend variable. It is designed to capture any trend in seasonal price movements that are not accounted for by the $Q_{shipment}$ variables and other variables in Equation 1. On average, Texas spring onion price declines $0.20 per sack per week beyond that due to increasing shipments from Texas, storage, Mexico and other new crop producers during the season. On average, the total number of onion shipments (from all sources) during the Texas shipping season is 6,138 truckloads in March, 7,857 truck loads in April, and 8,903 truckloads in May June, or roughly 350 truckloads per week. Thus the negative price effect of *WK_t* would accrue on top of the price depressing effects from these increasing shipments, which are quantified by the $Q_{shipment}$ variable coefficients (discussed below).

The insignificance of the income variable coefficient implies that income is not a significant predictor of onion demand and, consequently, South Texas onion price movement (Table 3). This result is not in agreement with previous studies, and could partially be an artifact of the data set due to our construction of a monthly income variable implies that it did not vary as much as the dependent variable.

The onion shipment variable coefficients and price flexibility calculations are of key interest. The shipment coefficients relate the change in weekly Texas price that results from a change in weekly shipments that are measured in truck load lots. An examination of these coefficients (Table 3) shows that each truckload of onions shipped from Mexico and South Texas during the South Texas marketing window reduces onion prices by $0.00108 per bag and $0.00105 per bag, respectively (note that the coefficients themselves are in inflation-adjusted dollar terms). The price impacts of shipments of storage onions and other U.S. new crop onions are similar, but smaller in their impact.

The coefficient estimates provide a means for quantifying the impacts of additional shipments from particular regions. For example, if Texas producers were to ship an additional 100 truckloads in a particular week, the South Texas price would be reduced by $0.105 per 22.7 kg (50 lb) bag or about $0.21/cwt. This in turn would devalue each truckload (and all other truckloads that week) by about $84. Similarly, if Mexico producers were to send an additional 100 trucks to the U.S. in a particular week, the price of Texas onions would decline $0.108 per sack (or $0.22/cwt). Or, we can say, the value of a truckload of Texas onions would decline about $86 per truckload in that week.

Further information is provided by the price flexibility estimates (Table 3), which show the percent change in price associated with a one percent change in shipments. The price flexibilities account for the magnitude of the quantity shipped from each region. For example, the regression coefficient on storage onion shipments is the smallest of the four regions, implying the least per truckload price impact. Yet the average quantity of storage onions shipped during the South Texas marketing window is so large that the storage onion shipments have the largest price impact in percentage terms (-0.1053). Recall from Table 2 that storage onion shipments average 402.21 truckloads per week. Suppose they increase shipments in a particular week by 1 percent or 4.02 truckloads. This will lower Texas price 0.1053 %, so if Texas price had been $8 per bag, it would be lowered to $7.99 per bag. If they had increased their shipments by 10 percent (40.2 truckloads), Texas price would decline 1.053% to about $7.92 per bag in the selected week.

The Q_{Mexico} flexibility from Table 3 is 0.06345 and they ship an average of 336 truckloads per week (Table 2). Suppose they increase shipments by 1 percent or 3.36 truckloads. This will lower Texas price .06345 % or $.0051 per bag if price had been $8/cwt. Suppose Mexico were to increase shipments by 2 % so that weekly shipments increased about 6.72 truckloads per week. In which case, Texas price would decline 0.1269 %. If Texas price had been $8/cwt, price would be lowered about $.0082/cwt to about $7.99 per bag (i.e., about the same as a one percent increase in storage shipments).

Summary. The contribution of this research is in quantifying onion price quantity relationships that heretofore have only been recorded as anecdotal reflections by industry observers. The quantification of these demand relationships should be useful as guidance to industry policy planners and shippers. For growers, quantifying the negative price impacts of increased shipments (by region) and weekly trends is useful for a number of management decisions, e.g., planting/harvest scheduling, break-even harvest decisions, etc.

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