Estimating the Market for Tomatoes

Rafi Melnick and Haim Shalit

An econometric model of the market for tomatoes in Israel is developed to take into account the distortions brought about by the marketing board and intermediaries. The existence of monopoly and monopsony power is hypothesized by analyzing the middlemen's optimal behavior. Being compelled by the marketing board to purchase all produce, wholesalers exert monopsony power by reducing quantities marketed to consumers by selling surpluses to the marketing board at the minimum price. The empirical results confirm the existence of strong monopsony power together with weak monopoly power in that market.

Key words: marketing boards, minimum price, monopoly power, monopsony power, price policy, tomatoes.

Agricultural price policy and regulation by governments and marketing boards greatly affect the market conditions of agricultural commodities. Hence, analyzing the behavioral interactions in the market becomes a complex task, especially when one includes the activities of intermediaries. The purpose of this paper is to analyze the market for tomatoes in Israel in all its aspects. This market is characterized by the special structure that has resulted from government intervention and the marketing practices that followed.

In the market for tomatoes one observes an unusually large spread between the consumer and the producer price for the product. This markup is explained by the existence of intermediaries along the marketing channels between consumers and producers. In addition, the system suffers from distortions when the government and the Vegetable Marketing Board intervene by setting minimum producer prices and production quotas and removing the excess supply from the market.

As economic theory now stands, applied market analysis consists of the joint estimation of the demand and supply relationships. However, it is common practice to justify separate estimation of demand and supply functions of perishable agricultural commodities by assuming that demand is short run whereas supply is generated in the long run. This is the approach taken in the present study which focuses on the monopolistic and monopsonistic power exerted by middlemen under government pricing and quantity regulations. By taking the market imperfections and government intervention into account, this analysis enables us to derive adequate demand and pricing functions and to estimate the economic power exerted by the intermediaries on sellers and buyers.

In this paper, we study the market for fresh tomatoes in Israel. The demand side is analyzed in a framework that disentangles the behavior of intermediaries and consumers. The conditions for monopoly and monopsony power are determined and an econometric model is estimated to test the market structure. A similar analysis has been performed for the California tomato processing industry by Just and Chern, who developed an empirical test for the presence of monopsony power. Here we present an alternative approach to measuring the market power in its different aspects, including the effects of government regulation.

The Theoretical Framework

Fresh tomatoes are produced all year round in Israel. Like most other vegetables, the tomato crop is regulated by the Vegetable Marketing Board. The board was designed mainly to en-

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This research was supported by a grant from the United States-Israel Binational Agricultural Research and Development Fund (BARD).

Review was coordinated by Peter Berck, associate editor.

sure a steady supply of vegetables to consumers by means of subsidies to producers. It was set up by the government to regulate the production and domestic sale of fresh vegetables and has the legal powers to enforce the regulations and to control the marketing of produce to the consumer.

One of the instruments used by the Vegetable Marketing Board is the allocation of production quotas to growers. These quotas are in terms of acreage, and their effect in determining the quantity produced is thus quite limited since, within the bounds set by current technology, yields can be changed at will. Producers who conform to the quotas are guaranteed a minimum price, and surplus tomatoes are removed from the market to be destroyed or channelled to canneries. The producer usually sells his entire output to an accredited wholesaler, who then markets the product to greengrocers, market retailers, and supermarkets. The wholesalers are able to fix the producer and consumer prices within the constraints imposed by the marketing board. In some cases, growers cooperatives act as wholesalers and handle the sale of products on a commission basis, but here too the wholesaler determines the price to consumers.

It is appropriate to center our analysis on the activities of the middleman, because his actions interfere in the normal interaction between the consumer and the producer and thus lead to departures from perfect competition. We analyze the elements that determine the markup between producer and consumer prices. Assume that intermediaries act as middlemen and exert their power on both sides of the market to increase their profit over the normal level. Consider a representative middleman whose objective function is to maximize his profit from the sale of produce. The middleman's profit, Π, is defined as

$$(1)\quad \Pi = P_cQ_c + (Q_s - Q_c)P_m - P_sQ_s - \theta Q_c \quad \text{s.t. } Q_s - Q_c \geq 0,$$

where P_c is consumer price per unit of commodity; Q_c, quantity demanded at price P_c; Q_s, quantity produced; P_m, minimum price guaranteed by the marketing board to producers; P_s, price paid to producers; and θ, handling cost per unit of the commodity.

Profit is defined as revenue from sales to consumers, (P_cQ_c), plus revenue from sale of surplus to the government $[(Q_s - Q_c)P_m]$, less the cost of purchasing the produce (P_sQ_s) and the handling costs (θQ_c). It is understood that the producer price, P_s, does not exceed the consumer price, i.e., $P_s \leq P_c$. Furthermore, the price paid to the producer cannot be below the minimum price, i.e., $P_m \leq P_s$. To be accredited by the marketing board, the wholesaler engages to purchase all the quantity produced by the growers, but he cannot pay less than the minimum price, P_m, for the crop. The excess supply may however be sold to the marketing board at the minimum price. The objective function is maximized by the wholesaler's choice of optimum Q_c. In the demand function this decision variable determines revenues and in the pricing function it determines costs. We will assume that there are few wholesalers and each of them exerts some monopoly power, which will be modeled as follows.

Define $P_c = D(Q_c)$ as the inverse demand function for the commodity and let α be the degree of monopoly power exerted by intermediaries, where $0 \leq \alpha \leq 1$, and $\alpha = 1$ represents complete monopoly power, $\alpha = 0$ represents perfect competition. Thus the consumer price, P_c, will depend upon α, so that for the wholesaler

$$(2)\qquad P_c = D(\alpha, Q_c)$$

with

$$\frac{\partial P_c}{\partial Q_c} = \alpha D'(Q_c).[1]$$

The parameter α represents the degree of monopoly concentration in the market and therefore shows to what extent the wholesaler in monopolistic competition can use marginal instead of average revenue as the pricing rule. Indeed, consider a fixed marginal cost, MC, and $P_cQ_c - MCQ_c$ reduce the monopolistic firm problem as maximizing $P_cQ_c - MCQ_c$. Then the first-order condition for this maximization is simply

$$P_c + P_c\frac{\alpha}{\epsilon} = MC,$$

where ϵ is the price elasticity of demand. This condition can be rewritten as

$$P_c(1 - \alpha) + \alpha P_c\left(1 + \frac{1}{\epsilon}\right) = MC, \text{ or}$$

$$AR(1 - \alpha) + \alpha MR = MC$$

[1] This form of specifying monopoly power assumes that it is independent of both the demand and quantity sold.

where AR and MR are average and marginal revenue, respectively. The smaller the α, the more competitive is the firm and the greater the inducement to use average-revenue pricing; whereas, in a highly concentrated market marginal-revenue pricing is the rule.

Consider now the supply side of the market with wholesalers purchasing the commodity from producers and paying P_s for it. This price depends on the degree of monopsony power the wholesalers can exert on the producers. In a pure monopsony, the wholesaler will pay the lowest price possible and the producer price will be the minimum price, P_m. The short-run supply is totally inelastic; thus the lower the degree of monopsony power, the greater the share of the profit which goes to the producer. In perfect competition, the producer price equals the consumer price less the handling costs, θ, which represent the normal markup, since normal profit is zero. Hence, the producer price will be a weighted-average function and will lie between P_m and $P_c - \theta$. As the degree of monopsony power increases, the weight assigned to P_m increases and the wholesaler captures a large share of the spread between P_s and $P_c - \theta$. Denoting this weight by β (referred to as the degree of monopsony power), we then obtain the producer price function,

$$P_s = \beta P_m + (1 - \beta)(P_c - \theta), \tag{3}$$

with $\beta = 0$ expressing perfect competition and $\beta = 1$ pure monopsony. The β parameter gives the share of the increase in the consumer price that is kept by the wholesaler since $\frac{\partial P_s}{\partial P_c} = (1 - \beta)$ is the share received by the producer. Since wholesalers must purchase the entire quantity supplied, their discretion is confined to deciding the quantity sold. Thus taking equations (2)–(3) into account, maximization of Π with respect to Q_c leads to the first-order conditions

$$P_c + \alpha D'(Q_c)Q_c = P_m + Q_s(1 - \beta)\alpha D'(Q_c) + \theta + \mu \tag{4}$$
$$\mu(Q_s - Q_c) = 0,$$

where μ is the Lagrange multiplier associated with the constraint $Q_s - Q_c \geq 0$.

To extend the analysis and gain understanding of the middleman's activities, four combinations of monopoly-monopsony power are presented.

(*a*) The first case is that of perfect competition on both sides of the market ($\alpha = 0$ and $\beta = 0$). In that case, the intermediary does not determine Q_c. The producer price, the consumer price, and the quantity consumed at these prices will be determined in the market in one of two distinct ways, according to whether or not P_m is effective. When the quantity supplied exceeds the quantity demanded at the minimum price plus normal handling costs, P_m is effective; hence,

$$P_c = P_m + \theta,$$
$$P_s = P_m,$$
$$Q_c = D^{-1}(P_m + \theta),$$
$$Q_e = Q_s - Q_c,$$

when $Q_s \geq D^{-1}(P_m + \theta)$ (Q_e is the surplus removed from the market).

If P_m is ineffective (the quantity supplied is smaller than the demand at P_m plus normal handling costs), we have

$$P_c = D(Q_s),\ P_s = P_c - \theta,\quad Q_c = Q_s,\ Q_e = 0$$

whenever $Q_s < D^{-1}(P_m + \theta)$.

(*b*) Consider now the case in which the middleman exerts some monopoly power on the consumer side ($\alpha > 0$) and there is perfect monopsony on the producer side ($\beta = 1$); condition (4) implies that the middleman equates his marginal revenue with his marginal cost ($P_m + \theta + \mu$). The condition becomes

$$MR(Q_c, \alpha) \equiv D(Q_c) + \alpha D'(Q_c)Q_c = P_m + \theta + \mu,$$

again with two distinct possibilities depending upon a surplus or not. In the first instance we have $\mu = 0$ and

$$P_c = P_m + \theta - \alpha D'(Q_c)Q_c \quad \text{if } MR(Q_c) \leq P_m + \theta.$$

In the second, no surplus is created since

$$\mu = D(Q_s) + \alpha D'(Q_s)Q_s - P_m - \theta \text{ and}$$
$$P_c = D(Q_s) \text{ if } MR(Q_s) > P_m + \theta.$$

Furthermore, the producer price, P_s, is in both cases equal to the minimum price for all quantities, since the middleman is a perfect monopsony. This situation is depicted in figure 1 for $\alpha = 0.5$ and for a linear demand function. Let Q^* be the quantity defined by $MR = P_m + \theta$, i.e., $MR(Q^*, a = 0.5) = P_m + \theta$. If the quantity supplied is $Q_s^A > Q^*$, the consumer price will be P^*_c as determined by $D(Q^*)$ and the quantity removed from the market will be $Q_e = Q_s^A - Q^*_s$. If the quantity supplied is Q_s^B

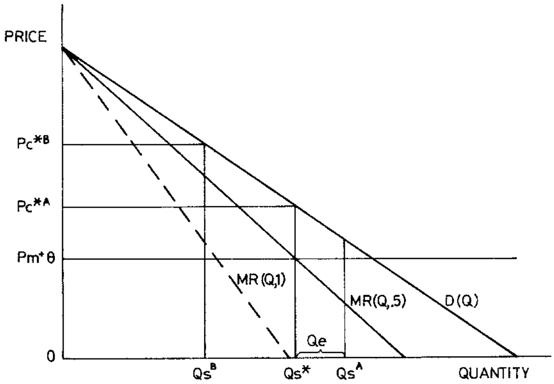

Figure 1. Surplus determination in the case of weak monopoly

$< Q^*$, the consumer price is determined by $D(Q_s^B)$ and there is no surplus.

(*c*) Consider now a monopolist wholesaler who lacks power in the producing sector. He must share his profits with producers and equate his marginal revenue with the marginal cost that includes this share of profits. In that case,

$$(5) \quad MR(Q_c, \alpha) \equiv P_c + \alpha D'(Q_c)Q_c = P_m + \theta + \alpha Q_s D'(Q_c) + \mu$$

$$\mu = \begin{cases} 0 & \text{if } Q_s \geq D^{-1}(P_m + \theta) \\ D(Q_s) - P_m - \theta & \text{if } Q_s < D^{-1}(P_m + \theta). \end{cases}$$

Thus, for $Q_s \geq D^{-1}(P_m + \theta)$, the wholesaler fixes the consumer price at $P_m + \theta$ since $\alpha D'(Q_c)(Q_s - Q_c)$ is negative. The consumer price is therefore

$$P_c = \begin{cases} P_m + \theta & \textit{if } Q_s < D^{-1}(P_m + \theta) \\ D(Q_s) & \textit{if } Q_s < D^{-1}(P_m + \theta) \end{cases}$$

Comparing this case with the monopoly-monopsony case (*b*) shows that the monopolistic middleman who lacks monopsony power must lower the consumer price since following equation (3) he must share his profits with producers. Therefore a middleman cannot exploit his monopolistic position unless he exerts some kind of monopsony power. This result is derived from the fact that the regulations compel the middleman to handle the entire quantities produced under production quotas.

(*d*) Consider a monopsonist wholesaler without monopoly power in the consumer sector; the results are

$$P_c = \begin{cases} P_m + \theta & \text{if } Q_s \geq D^{-1}(P_m + \theta) \\ D(Q_s) & \text{if } Q_s < D^{-1}(P_m + \theta) \end{cases}$$

and $P_s = P_m$ for all Q_s.

The Linear Demand Case

Assume a linear inverse demand function of the form $P_c = a - bQ_c$. Then $D'(Q_c) = -b$. For this linear demand, we will analyze the interesting case of $\alpha > 0$ and $\beta > 0$, where the middleman's maximum profit is obtained by solving

$$P_c - \alpha b Q_c = P_m - Q_s(1 - \beta)\alpha b + \theta$$

with $Q_s = Q_c$.

The quantity supplied at which no surplus is created and which maximizes the middleman's profit is $Q_c = Q_s = (a - P_m - \theta)/b(1 + \alpha\beta)$. If Q_s increases, the middleman is induced to create a surplus. The consumer price will nevertheless decrease for $\beta < 1$, since he shares his profit with the producers, i.e.,

$$(6) \quad P_c = \frac{P_m + \theta - \alpha[b(1 - \beta)Q_s - a]}{1 + \alpha}.$$

If Q_s is very large, $[b(1 - \beta)Q_s - a]$ becomes positive and the consumer price theoretically can fall below $P_m + \theta$. However, this will not happen because P_m is the minimum price, i.e., $P_c = P_m + \theta$ for any $Q_s > (a - P_m - \theta)/(1 - \beta)$.

The results of the middleman's actions in the various monopoly-monopsony power combinations are summarized in table 1 for a linear inverse demand function.

Estimation of the Model

The short-run model of the fresh tomato market is characterized by an exogenously fixed supply, Q_s. Fresh tomatoes can be stored to a limited extent, and the limit is assumed to be one month (since we use monthly data).

The theoretical framework presented in the preceding section leads to a structural econometric model consisting of three behavioral equations and one identity. These equations determine four endogenous variables: the consumer price, the producer price, the surplus, and the quantity consumed. The first behavioral equation is the ordinary demand function; the second is the producer pricing function, which is specified to estimate the degree of monopsony power; the third is the surplus which is derived from the middleman's profit-maximizing behavior, his monopoly and monopsony power, and the minimum price in

Table 1. The Middleman's Actions in the Various Monopoly-Monopsony Power Combinations

Monopsony Power	Monopoly Power $\alpha = 0$	Monopoly Power $\alpha > 0$
$\alpha = 0$	if $Q_s \geq \frac{a - P_m - \theta}{b}$ $P_c = P_m + \theta$ $Q_c = \frac{a - P_m - \theta}{b}$ $P_s = P_m$ if $Q_s < \frac{a - P_m - \theta}{b}$ $P_c = a - bQ_s$ $Q_c = Q_s$ $P_s = P_c - \theta$	if $Q_s \geq \frac{a - P_m - \theta}{b}$ $P_c = P_m + \theta$ $Q_c = a - P_m - \theta$ $P_s = P_m$ if $Q_s < \frac{a - P_m - \theta}{b}$ $P_c = a - bQ_s$ $Q_c = Q_s$ $P_s = P_c - \theta$
$\alpha > 0$	if $Q_s \geq \frac{a - P_m - \theta}{b}$ $P_c = P_m + \theta$ $Q_c = \frac{a - P_m - \theta}{b}$ $P_s = P_m$ if $Q_s = \frac{a - P_m - \theta}{b}$ $P_c = a - bQ_s$ $Q_c = Q_s$ $P_s = P_m + (1 - \beta)(P_c - P_m - \theta)$	if $\frac{a - P_m - \theta}{b(1 + \alpha\beta)} \leq Q_s \leq \frac{a - P_m - \theta}{1 - \beta}$ $P_c = \frac{P_m + \theta - \alpha[b(1 - \beta)Q_s - a]}{1 + \alpha}$ $Q_c = \frac{a - P_c}{b}$ $P_s = P_m + (1 - \beta)(P_c - P_m - \theta)$ if $Q_s > \frac{a - P_m - \theta}{1 - \beta}$ $P_c = P_m + \theta$ $Q_c = \frac{a - P_m - \theta}{b}$ $P_s = P_m$ if $Q_s < \frac{a - P_m - \theta}{b(1 + \alpha\beta)}$ $P_c = a - bQ_s$ $Q_c = Q_s$ $P_s = P_m + (1 - \beta)(P_c - P_m - \theta)$

force. This equation is essentially a Tobit relationship since the surplus is zero when the quantity supplied does not exceed the limit given by the necessary conditions and positive otherwise. Another endogenous variable is provided by the identity $Q_c \equiv Q_s - Q_e$, which states that the quantity consumed equals the quantity offered to the market by the middleman after the surplus has been removed to the marketing board at the guaranteed minimum price.

The Demand Equation

The demand model has become the classic example of problems in single-equation estimation of a simultaneous-equation model. The main problem resides in the correlation between the explanatory variables and the stochastic disturbance, which can bias the results from ordinary least squares estimation (OLS). This need not happen in agricultural markets since, as with tomatoes, short-term supply is exogenously fixed. Furthermore, as shown above, the quantity channeled to the consumers, Q_c, is determined by the profit-maximizing behavior of the middleman, who, among other things, uses the parameters of the demand equation to define the quantity to be supplied to the market. This quantity, although endogenous in the model, is not affected by the stochastic disturbance of the inverse demand equation. A simple regression model of the consumer price on the quantity purchased by the consumer and all the other relevant variables affecting the demand can therefore be consistently estimated by OLS. This point will be further explored by estimating the demand relation using two-stage least squares (2SLS) with P_m and Q_s as additional exogenous variables, and comparing the results with OLS.

As usual, an inverse relationship between the consumer price and the quantity consumed is expected. The other variables affecting the consumer price are (*a*) the level of income, Y, which is expected to be positively related to the consumer price since tomatoes are assumed to be a normal good; and (*b*) the price of substitutes, P_a, which is expected to be positively related to the consumer price (P_a is the price index of all other vegetables weighted by their share in the budget for vegetables expenditure). The basic equation is therefore

$$(7) \qquad P_c = D(Q_c, Y, P_a, \epsilon)$$

where ϵ is the stochastic disturbance.

The linear and log-linear inverse demand functions are presented in table 2. The first equation presents the OLS results using dummy variables for monthly variations and one lag of the dependent variable.[2] The use of P_{ct-1} is justified by the existence of dynamic factors which result in the short-run reactions to changes in the exogenous variables differing from the long-run reactions. Furthermore, as shown in regression (3), serial correlation is evident in the OLS estimates and the basic equation is estimated using the Cochrane-Orcutt procedure (CORC) [regression (4)].

The first equation with the lagged dependent variable exhibits the best results, although the income parameter is negative. A possible explanation is that, as a proportion of income, tomato consumption has decreased and has become an inferior good over the years. The results are quite similar to those obtained by Mundlak for data on an earlier period. Furthermore, as shown by regression (5), 2SLS estimation does not yield significantly better results, indicating that OLS provides consistent estimators for the demand parameters.

The greater-than-unity price elasticity of demand is evidence of the existence of potential monopoly power in the market. Although not sufficient, this result is a necessary condition for potential monopoly power to be activated, i.e., for some quantity to be removed from the market by sale to the marketing board.

The Producer Price Function

The pricing function defines the producer price as dependent on the consumer and the minimum price. It reflects the degree of monopsony power exerted by the middleman. In perfect competition, the middleman's markup consists only of a normal cost which includes transport, handling costs, spoilage, and normal profit. On the other hand, in a pure monopsony, producer price will be close to the minimum price since the middleman exerts all his power. This behavior is modeled by the function $P_s = f(P_c, P_m, \theta, \beta)$, whose linear form is

$$(8) \quad P_s = -(1 - \beta)\theta + \beta P_m + (1 - \beta)P_c$$

where θ is the normal markup and β is the degree of monopsony power. Table 3 presents the linear and log-linear estimates of the pricing function. Both specifications are estimated by OLS and CORC, equation (8) being estimated as

$$P_s = b_0 + b_1P_m + b_2P_c + \epsilon.$$

Furthermore, using a nonlinear squares (NLSQ) procedure, equation (8) is estimated directly under the constraint that the coefficients of P_m and P_c sum to unity. This constraint enables us to obtain a direct estimate of θ.

The unconstrained linear form yields negative (not significantly different from zero) estimates for θ, the normal markup. This value is corrected when the sum of the coefficients of P_m and P_c is constrained to equal unity (NLSQ estimation). We then obtain highly significant estimates of both θ and β. A simple F-test does not reject the hypothesis that the sum of the coefficients is unity. It appears that the

[2] Only three months have shown significant variations from the common intercept.

Table 2. Inverse Demand Function Estimates, January 1966–December 1980 (168 monthly observations)

	Linear					Log-Linear				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	3.81	3.8	4.54	5.4	4.50	1.02	0.88	1.8	2.28	1.44
	(3.8)	(3.6)	(3.9)	(4.2)	(4.2)	(1.2)	(1.0)	(1.8)	(1.7)	(1.6)
Q_c	−1.34	−1.57	−1.27	−1.31	−1.54	−0.30	−0.36	−0.28	−0.28	−0.52
	(−7.6)	(−9.2)	(−6.3)	(−6.8)	(−7.6)	(−5.9)	(−7.4)	(−4.6)	(−4.9)	(−8.2)
Y	−0.001	−0.001	−0.001	−0.001	−0.001	−0.15	−0.15	−0.24	−0.28	−0.17
	(−2.8)	(−2.7)	(−3.3)	(−2.7)	(−3.0)	(−1.3)	(−1.3)	(−1.8)	(−1.5)	(−1.5)
P_a	0.87	0.98	1.14	0.99	0.82	0.85	0.97	1.15	0.99	0.77
	(5.9)	(6.8)	(7.1)	(5.4)	(5.6)	(7.8)	(9.5)	(9.3)	(7.6)	(6.5)
$P_{c,t-1}$	0.33	0.39			0.33	0.38	0.41			0.39
	(7.4)	(8.7)			(7.4)	(8.2)	(9.4)			(8.0)
Month										
March	0.77		0.77	0.77	0.71	0.15		0.15	0.15	0.10
	(2.6)		(2.2)	(2.4)	(2.4)	(2.5)		(2.3)	(2.4)	(1.7)
April	1.37		1.99	1.70	1.27	0.17		0.32	0.25	0.09
	(4.5)		(5.9)	(5.3)	(4.1)	(2.8)		(4.6)	(3.9)	(1.4)
June	0.18		0.68	0.37	0.25			0.11	0.04	
	(0.6)		(2.0)	(1.2)	(0.84)			(1.7)	(0.7)	
SER[b]	0.96	1.02	1.11	1.07	0.96	0.19	0.19	0.23	0.22	0.22
R^2	0.74	0.71	0.65	0.68		0.75	0.72	0.63	0.65	
h or D.W.[c]	−0.88	−1.18	1.55*	1.44*[a]	2.08	−1.31	−0.94	1.58*	1.44*[a]	
Method	OLS	OLS	OLS	CORC	2SLS	OLS	OLS	OLS	CORC	2SLS

Note: Prices are in Israeili pounds (IL) deflated by CPI (1976 = 100); mean P_c = IL 4.29/kg. Quantities in kg. are per capita; mean Q_c = 1.99 kg. per capita. Figures in parentheses are t-values.

[a] The serial correlation coefficient is $\rho = 0.28$ ($t = 3.8$).

[b] Standard error of the regression.

[c] Durbin-Watson stochastic for * entry, h-statistic elsewhere.

log-linear representation, which yields similar parameter estimates in all three estimations, is more robust to the method of estimation. The parameter estimates of table 3 are consistent only under the assumption that the stochastic disturbances of the pricing function and the demand equation are uncorrelated. In that case, the two equations form a recursive block implying that OLS provides consistent estimates in spite of the fact that P_c is an explanatory variable and endogenous in the system. However, if the disturbances of the demand and pricing equations are correlated, the OLS estimates of the demand function, although consistent, are not efficient because of the usual seemingly unrelated regression property.

Surplus Equation

The results of table 1 describe the middleman's profit-maximizing behavior, by which the level of consumption is determined. This condition is given by the censoring function

$$Q_c \geq g[Q_s, P_m, \alpha, \beta, D(\cdot), \theta]$$

where α represents monopoly power, β monopsony power, and $D(\cdot)$ represents the parameters of the demand function. Since Q_s is exogenous, the quantity channeled to the market follows a censoring procedure characterized by the process

$$(9)\quad Q_c = \begin{cases} Q_s & \text{if } Q_s < h[P_m, \alpha, \beta, D(\cdot), \theta] \\ g(\cdot) & \text{if } Q_s > h[P_m, \alpha, \beta, D(\cdot), \theta], \end{cases}$$

where $h(\cdot)$ is the censoring function used by the middleman, and is shown below for the linear demand function $P_c = a - bQ_c$. The censoring mechanism for the case $\alpha > 0$, $\beta > 0$ as derived in table 1 is presented in figure 2. The solid line represents the quantity sold to consumers. To the left of the first critical point, A, the quantity consumed, Q_c, equals the quantity supplied, Q_s, and there is no surplus, ($Q_e = 0$).

Between points A and B, as Q_s increases, so does Q_c, but more slowly, and Q_e is shown by the vertical distance between the 45° line and the solid line. At point B, Q_c reaches the maximum consistent with the minimum price, P_m. Here, any additional unit of output, Q_s, is

Table 3. Producer Price Function

	Unconstrained Estimates				Constrained	
	Linear		Log-Linear		Linear	Log-Linear
	OLS	CORC	OLS	CORC	NLSQ	NLSQ
Constant	−0.16	−0.18	−1.17	−1.12		
	(−1.5)	(−1.2)	(−14.3)	(−12.6)		
P_m	0.09	0.10	0.23	0.31		
	(1.0)	(0.8)	(3.3)	(3.1)		
P_c	0.39	0.39	1.08	1.04		
	(21.7)	(21.1)	(18.4)	(17.6)		
θ					1.85	1.92
					(16.5)	(25.3)
β					0.64	0.46
					(34.8)	(26.3)
R^2	0.79	0.83	0.75	0.83	0.74	0.72
D.W.	1.1	2.0	0.9	1.9		
ρ		0.44		·0.57		
		(6.3)		(8.9)		

Note: Prices are in IL/Kg., deflated by the CPI (1976 = 100); figures in parentheses are t-values.

added to the surplus and sold to the marketing board. The censoring function can conveniently be expressed in terms of the surplus quantity; that is,

$$(10)\quad Q_c = -\frac{a-\theta}{b(1+\alpha)} + \frac{(1+\alpha\beta)}{(1+\alpha)}Q_s + \frac{1}{b(1+\alpha)}P_m,$$

for the segment AB

$$Q_e = Q_s - \frac{a - Pm - \theta}{b}$$

for points to the right of B.

As was shown in table 1, the consumer price will be very close to the minimum price, since the quantity supplied exceeds the second critical point, B. Although this is a theoretically possible situation, our data show that the consumer price was considerably above the minimum price in all periods considered, so that empirically no harm is done by neglecting this possibility.

To obtain the specification of the surplus equation the equation is reparameterized as

$$\delta_0 = -\frac{(a-\theta)}{b(1+\alpha)};\ \delta_1 = \frac{1}{b(1+\alpha)};$$

$$\delta_2 = \frac{1+\alpha\beta}{(1+\alpha)}.$$

Then

$$(11)\quad Q_e = \begin{cases} 0 & \text{if } \delta_0 + \delta_2 Q_s + \epsilon \leq 0 \\ \delta_0 + \delta_1 P_m + \delta_2 Q_s + \epsilon & \text{if } \delta_0 + \delta_1 P_m + \delta_2 Q_s + \epsilon > 0 \end{cases}$$

where ϵ is a normally distributed disturbance.

This is a Tobit model whose coefficients can be estimated by a maximum-likelihood procedure, since it is clear that, given the specification of the surplus equation, OLS estimates will be biased. The Tobit model is therefore estimated by a procedure developed by Heckman. First, a probit analysis is carried out on equation (11) to estimate, for each observation, the probability of positive surplus. The reciprocal of Mill's ratio is then computed as

$$\hat{\lambda} = \frac{f(\hat{\phi})}{1 - F(\hat{\Phi})}$$

where $\hat{\phi} = -(\hat{\delta}_0 + \hat{\delta}_1 P_m + \hat{\delta}_2 Q_s)$, $\hat{\delta}_0$, $\hat{\delta}_1$, $\hat{\delta}_2$ are the probit estimates, $F(\cdot)$ is the normal cumulative probability distribution function, and $f(\cdot)$ is the normal density function. Since $[1 - F(\hat{\phi})]$ is the probability that $Q_e > 0$, the lower that probability, the greater will be the value of $\hat{\lambda}$; thus correcting the equation for positive Q_e.

The next stage consists of estimating equation (11) by OLS as

$$Q_e = \delta_0 + \delta_1 P_m + \delta_2 Q_s + \delta_3 \hat{\lambda}.$$

The estimation yields consistent estimates of

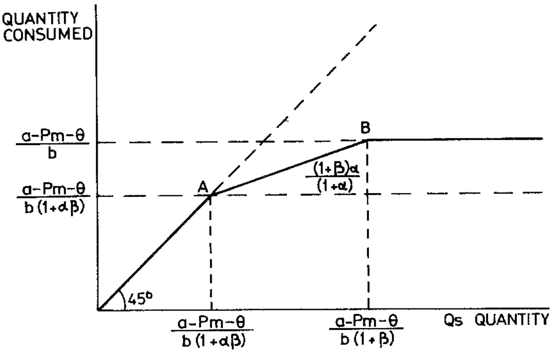

Figure 2. Determination of surplus in the case of the middle man

the parameters since the $\hat{\lambda}$ estimated from the probit analysis is a consistent estimator of the true λ.

The two-stage estimates of the surplus equation are presented in table 4. Comparing the coefficients of Q_s and P_m in the OLS estimations with positive Q_e, we see how the bias is corrected. The coefficient of Q_s increases from 0.39 to 0.86 and that of P_m from 0.034 to 0.18. Furthermore, the statistical significance of the estimates increases considerably, particularly for the coefficient of P_m.

However, the coefficients of the surplus equation are nonlinearly related to the coefficients of the demand equation and to those of the pricing function. The only new parameter that must be estimated in the surplus equation is thus the degree of monopoly power, α, exerted by the middleman. This parameter is estimated by substituting the values of the parameters estimated by equations (7) and (8) into equation (10). The estimate of α obtained from nonlinear least-squares is $\hat{\alpha} = 0.18$ with standard deviation of 0.09.

Table 4. Surplus Equation

	All Observations		Observations with Positive Q_e	
	OLS	Probit	OLS	OLS Corrected
Constant	−0.67	−5.98	−0.67	−2.62
	(−7.8)[a]	(−5.8)	(−7.8)	(−5.3)
Q_s	0.37	1.78	0.39	0.86
	(16.4)	(6.4)	(15.4)	(7.2)
P_m	0.07	0.43	0.03	0.18
	(1.5)	(0.8)	(0.61)	(2.8)
λ				0.37
				(3.9)
R^2	0.62		0.62	0.66
D.W.	1.67		1.62	1.72

[a] Figures in parentheses are t-values.

Conclusions

This paper has presented an econometric model of the market for tomatoes in Israel. Although the market is characterized by a large number of producers and consumers, its structure is not competitive since, in spite of government regulation, it has allowed middlemen to exert power on the two sides of the market. Since wholesalers are compelled by the marketing board to purchase the entire quantity supplied by the producers, the monopsony power is not applied by restricting the quantities supplied but by depressing the price to the producer. On the consumer side, monopoly power is exerted by reducing optimally the quantity marketed to consumers by selling to the marketing board, at the minimum price, surpluses generated at above-minimum prices. The parameters measuring the degree of monopsony and monopoly power are determined by the middleman's optimal behavior. The method used allows us to obtain these parameters from a small number of variables, an advantage when applying this approach to other industries.

The empirical results show that despite government regulations that fix minimum prices and require the purchase of the entire quantity supplied, there are strong signs of monopsony power in the market. That is, with $\beta = 0.64$ middlemen are less willing to share the consumer price with producers. On the consumer side, one observes that the parameter estimating monopoly power is relatively low, $\alpha = 0.18$, showing that marginal revenue pricing is not of common occurrence. Thus monopoly power is not present in the Israeli tomato market.

The relative size of these parameters shows that the chief sufferer is the farmer, who receives less revenue for his product. This implies the need for administrative measures aimed at reducing the markup to the farmer's advantage. One such policy would be to reduce concentration in the intermediary market by permitting the number of wholesalers to increase. At present their number is limited by law and new trade permits ("medallions") are not issued. The reason for this policy is mainly the marketing board's preference for dealing with a small number of wholesalers. However, as shown in the present study, this policy has adverse effects on farmers' welfare. As to consumers, there is no need for further adjustment since, as shown by the relatively small degree of monopoly power, the large number of retailers ensures a fairly competitive market for consumers.

[*Received March 1983; final revision received July 1984.*]

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