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Price supply response of vegetable growers in the Sultanate of Oman

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Abstract

Information on supply price elasticities has been acknowledged as being very important for decision makers at the macro and micro levels. This paper presents an empirical investigation of vegetable growers' responses to prices in Oman. It develops a single supply response function incorporating adaptive expectation model for prices. Results indicate that growers adjust relatively fast to changes in expected prices. However, these adjustments are rather low for some crop in the short- and long-run. Growers' production decisions have also shown a significant response to prices of other products competing for farm space and other production resources. These results will support efforts aimed at market development and crop enhancement programs. © 1998 Elsevier Science B.V. All rights reserved.

Keywords: Sultanate of Oman; Supply; Response; Vegetables; Adoptive expectation

1. Introduction

The need for farmers' price response has been acknowledged for a long time for policy purposes (Adelaja, 1991; Chen and Ito, 1992; Nerlove, 1956). Information about supply price elasticity in general allows the formulation of appropriate agricultural price policies and helps understand and predict short-run and long-run impacts of price changes on production. Knowledge of impacts of prices on crop choices is also important for understanding the dynamics of growers, why farmers change from one crop to another. It could also be useful in planning government programs and services the distribution of which is based on production behavior and response to prices.

In Oman vegetable production is an important part of the cropping system. It includes crops essential to the Omani (local) diet and some of the more common export commodities. Available information indicates that vegetable production has developed remarkably during the last two decades. Production and productivity as well as cultivated areas have tended upward since the 1970s (Omezzine, 1997). However, recent studies reveal that the development of vegetable production has often resulted in domestic market saturation and depressed prices. Sharp fluctuations in area and production as well as price changes from one season to another have been observed (Omezzine, 1997). In the face of these price fluctuations production decisions have included short-run and long-run adjustments. Descriptive analysis of these adjustments indicates that vegetable growers in Oman make production decisions primarily on price expectations under prevailing market conditions (Omezzine,

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1997). Recent survey data (DAERS (1994)) indicate that vegetable growers in Oman have a substantial long-run response to prices in producing individual crops. They react to a price they expect and this expected price depends only to a limited extent on what last year's prices were. However, the magnitude of growers' price response has not been measured. No estimates of supply price elasticities exist for Oman. Yet, quantitative knowledge of growers' response to changing prices is of considerable importance in evaluating efforts for market development and cropping system enhancement. The cropping system has included a variety of low-value traditional vegetables for local consumption while current agricultural conditions support potential production of higher value crops for the export market (JICA, 1990; Omezzine, 1997). Farmers' behavior may assist in designing a cropping system that favors optimal crops. Supply response information may also be needed by the private sector to make investment decisions in the distribution of vegetables. The system is now promoting new companies to take over the role of a government-owned and financed marketing authority.

This paper presents an empirical investigation of vegetable growers' response to prices. It explores general methods of evaluating short- and long-run supply price elasticity for selected crops. The main purpose of the paper is to measure short- and long-run response to prices and their adjustment to changed market conditions.

2. Theoretical background

Supply response studies have been widely surveyed by many economists. Comprehensive reviews of these studies have been provided by Askari and Cummings (1977), Behrman (1989), Rao (1989), Ozanne (1992) and Mamingi (1997). The more recent as well as the older studies indicate that the traditional single equation analysis and time series data have been very popular in estimating supply equations for individual annual crop (Nerlove, 1958; Trail et al., 1978; Jaforullah, 1993).

Panel data have been also used to analyse supply response. Producers' behavior and responsiveness to product prices are analyzed through survey data. Answers given by producers are based on the relative

prices at the time of the survey. If relative prices change the supply schedule derived at another time from the particular panel would be different. Panel approach has been described as subjective method as it relies heavily on producers' judgment and past data involving imperfect knowledge and personal biases of the respondents.

Supply estimation based on time series analysis has its roots in the post-war period. Nerlove's, 1958 work has been recognized as the most significant contribution to this field of investigation. Nerlove's development of the distributed lag models has contributed to the estimation of short-run and long-run elasticity of supply. Several problems have been encountered in estimating supply response. Nerlove, 1961 and Bachman, 1961 have identified five categories of these problems, namely, (1) complex structure of production, (2) technological change, (3) aggregation, (4) investments in fixed or quasi-fixed factors and (5) uncertainty and expectations.

The complex structure of agricultural production and its dependence on other sectors of the economy involve a relatively high number of variables to include in the supply function. This may not be always possible and calls for the aggregation of some variables and often elimination of others. Moreover, major changes in technology, institutions and government policies cannot always be incorporated in supply equations. These problems have been recognized in recent studies of agricultural supply response where various concerns have been raised. A comprehensive review of these issues may be found in Mamingi (1996, 1997), Jaforullah (1993) and Hallam (1990) among the more recent references.

The specification of supply response equations is based on variables and structures expected to exist in the future. Predicted future supply relationship based upon the observed relationship that existed in the past may lead to problems of specifying farmers' expectations. This has involved implicit assumptions about farmers' level of knowledge and understanding of the economic relationship. Farmers may recognize some of the important factors affecting product prices, but they may not go through the complex process of assessing the relative importance of these factors in developing expectations.

Specifications of agricultural supply response functions lie on the assumption that farmers base their

productive decisions and choices of crops to be cultivated in a given season on some reasonable assessment of the supply and demand conditions that may prevail at harvesting time (Sherma, 1992; Nerlove, 1961). Expected prices of the product and its competitor products are implicit to supply response specifications because of the time lag between production decision and harvesting time. Numerous proxies have been used to represent expected prices as a function of past prices. The Nerlove distribution lag model has been widely used and considered as the most influential model to capture crop supply. This model is based on price expectation and output adjustment (Mamingi, 1997). The model assumes that farmers revise their expected price in proportion to the error they may have made in previous years. This revision is made on the basis of an adjustment coefficient the value of which indicates how farmers respond to price changes over time.

Implicit to the definition of expected prices is the relevant price deflator. Askari and Cummings (1977) suggested four possible alternatives to account for real output prices, namely, (1) the ratio of price received by farmers to the consumers price index, (2) the price actually received by farmers, (3) the ratio of the farmers' price to the price of the most competitive crop and (4) the ratio of the farmers' price to the price index of farmers' inputs.

Supply response models have been expressed in both acreage and total production forms. They have generally included, in addition to the expected price of the product, expected prices of its competitors for land and production resources, input costs, government policies and many other factors that may have a potential impact on decisions to produce (Mamingi, 1997).

In the case of individual annual crop supply response the literature shows that the estimated supply response equation has raised major issues of misspecification, simultaneity, asymmetry, and back-bending supply curve. The problem of omitted variables remains a major concern in supply response. Models that have excluded many factors other than pure agricultural incentives to supply such as public inputs, research, extension, road density, government policies (Mamingi, 1997), population density (Krautkraemer, 1994), and rural infrastructure may be misspecified. Extensive use of time trend in supply response equa-

tions to capture effects of omitted variables could be justified by the lack of availability of data or multicollinearity among variables. However, it is recommended that the time trend variable be used as a last resort when tracing effects of important variables on supply response (Mamingi, 1997).

Although many studies have used a single equation to estimate supply response, simultaneity remains a major concern. The argument is that price and supply are simultaneously determined in which case estimates of a single equation may suffer a demand/supply simultaneity bias. This identification problem can be readily solved for some agricultural commodities because current production in most cases is not influenced by current prices but by past prices. Independent systems were chiefly advocated by the Cowles Commission. The basic idea underlying this approach is that economic data are generated by system of relations that are, in general, stochastic, dynamic and simultaneous (Shuffit, 1954; Clevanger and Shelly, 1974). Recourse to the exogeneity test to decide on simultaneity is very important (Mamingi, 1997).

Asymmetry or irreversibility of supply response has been confirmed in many studies (Jaforullah, 1993; Johnson, 1958). Price increase and decrease do not have the same effect on supply response.

Few studies have dealt with the problem of back-bending supply curves (Ozanne, 1992). It is argued that supply curves for agricultural products may be backward-bending with certain price ranges (Ozanne, 1992). This suggests that for a given price range farmers would produce more when prices decrease and vice versa. However, this may happen only under special conditions that apply mostly to subsistence or peasant farmers. In commercial agriculture (market-oriented), however, positive supply response to prices should be expected (Boussard, 1985).

Finally, supply response model estimation poses problems. As a general rule, most time series models exhibit a great deal of serial correlation. For this reason Ordinary Least Squares (OLS) estimates are unbiased but inefficient (Adelaja, 1991). Models with lagged variables also introduce serial correlation. The presence of lagged variables may yield OLS estimates that are biased and inconsistent. In the case of adaptive expectation models OLS parameter estimates are also biased and inconsistent (Pindyck and Rubinfeld,

1981). This results from a high correlation between regressors and error terms. Recommended estimation procedures include instrumental variables and, maximum likelihood (ML) techniques (Adelaja, 1991; Johnson, 1972).

3. The fresh vegetable sector in Oman and growers' production behavior

Fresh vegetable production in Oman is very important. It has developed remarkably during the last two decades to meet increasing domestic demand and to substitute for expensive imports. Production and productivity as well as cultivated areas have improved significantly during the last decade. Total area has grown from 3,481 ha in 1982 to 6,174 ha in 1995. Production has almost tripled during this same period going from 54,000 tons to 153,500 tons. Tomatoes, cucumber, onion, garlic, pepper, and watermelon are the most common vegetable crops grown.

The agricultural production structure remains dominated by a large number of small producers. More than 91% of the total farm holdings have an area of less than 5 ha and occupy more than 52.4% of total cropped land. In spite of this small size, production is market-oriented and uses new farming technologies including hybrid seeds, commercial fertilizers and pesticides, mechanization and water-saving irrigation systems.

Vegetable production comes during an average of six months a year (December/May) with a peak of most common crops in January/March. All this production is marketed primarily in the domestic market. Exports have been very limited and sporadic as Oman is still below self-sufficiency in vegetables. Domestic demand is by far higher than local production (JICA, 1990).

The domestic marketing system for vegetables is broad and involves several agents including small merchants, wholesalers, and retailers. However, the Public Authority for Marketing Agricultural Produce (PAMAP), a government-owned and financed institution, was the dominant distribution agent for vegetables and fruits in Oman from 1985 to 1994. Yet PAMAP's role has declined since 1994 after the removal of government financial support in attempt to bring private investment into agricultural market-

ing. Farmers react to market and non-market signals to decide on what and how much to produce. Survey results (DAERS, 1994) indicate that vegetable growers in Oman react to many factors. The most important factor, however, is the price of crops. For a particular crop, production is affected by its own price and other crop prices. Most growers recognize competition among crops for agricultural land and water resources specifically. A higher expected own price will tend to increase the production of a particular crop while higher prices of competing crops may result in decreased area and production of this particular crop. However, farmers claimed that substitutability is very specific between crops. Cross-price effects as generated by the survey results are summarized Table 1.

Farmers indicated that all crops may have negative cross-price effects with tomato. Cucumber, potato and garlic are the most affected crop by tomato price changes. Low expected prices of tomato may induce higher production of other crops. A reasonable justification for this behavior lies in the perishability of the tomato and long-time problems of market saturation.

However, depressed melon and watermelon prices may favor cucumber and tomato production while melon and watermelon may have mutual cross-price effects. Onion may not be a potential competitor for all crops except for garlic and pepper while garlic and onion may have mutual cross effects. Potato price may not have a significant effect on all crops. Pepper price change may affect watermelon and to a lesser extent sweet melon.

Moreover, vegetables compete with field crops mainly Rhodegrass and alfalfa. During the last 3 years farming systems in some regions have shifted to include more field crop production and less vegetables because of higher prices and less marketing difficulties for animal feed. Market conditions are also another major factor that affect farmers' response. The local marketing system for fruits and vegetables has been dominated by a large number of small private dealers with a low business profile. The market structure has not met the conditions of workable competitive market (Omezzine, 1997). Most market channels show evidence of lack of arbitrage and weak vertical coordination.

The foreign market is still limited to a few neighboring Gulf countries and characterized by keen competition as all countries have very similar produc-

Table 1
Cross-price effect matrix^a

Crop Area or Production	Crop Price									
	Tomato	Cucumber	Water-melon	Sweet melon	Onion	Garlic	Potato	Pepper	Cabbage	Okra
Tomato		–	++	+	–	–	–	–	–	–
Cucumber	+		–	+	–	–	–	–	–	–
Watermelon	+	+		++	–	–	–	++	–	–
Sweet melon	+	+	++		+	–	–	+	–	–
Onion	++	–	–	–		+	–	+	–	–
Garlic	+	–	–	–	++		–	–	–	–
Potato	++	–	–	–	–	+		+	–	–
Pepper	+	–	+	+	++	+	–		–	–
Cabbage	+	–	+	+	–	–	–	–		–
Okra	+	–	–	–	–	–	–	+	+	

Source: Compiled by authors from survey data collected through study survey (DAERS, 1994).

^a Farmers' answers were tested for statistical significance using Chi-square statistics.

+ Significant at more than 20% and less than 40% level.

++ Significant at less than 10% level.

– Not significant.

tion and marketing conditions. The few vegetable exports that have taken place have not emerged from a careful evaluation of market opportunities; rather they have resulted from individual initiatives by growers or traders at harvest time. Farmers indicated that increased exports to the neighboring United Arab Emirates market encourage them to produce more as more demand is created for the product.

The Government of Oman has been heavily involved in the development of agricultural production through a wide subsidy and extension program.

Vegetables, likewise fruits and field crops, have shared equally these governments' services. Commercial fertilizers, hybrid seeds, insecticides, irrigation system and farm equipments were subsidized equally for all crops. Meanwhile, free technical assistance through extension has been provided for all crops without distinction. These subsidies have decreased equally for all crops since the 1994/95 season for a total removal planned in three years.

4. The model and estimation procedure

The model presented here uses Nerlove's distributed lag specification. Supply response is measured in terms of quantity or acreage response with respect to prices. Farmers are assumed to make their production decision on their assessment of future market condi-

tions based on their experience and available information. They are more likely to plant more of a crop the following year if they perceive the prices of that crop to be high and vice versa. Moreover, in the short run it is assumed that the most important cost involved in the production of one crop is the lost opportunity to produce another crop. The most important cost factor for a crop then is the quantity of other crops not produced or reduced. This cost is identified as the expected price of other crops P_{jt}^* . Farmers' production decisions are also assumed to be affected by many other factors such as government subsidies, technology, weather, market conditions, etc. to count for government assistance in vegetable production.

The supply function is then specified for a given crop as follows:

$$Y_{it} = \beta_{i0} + \beta_{i1}P_{it}^* + \beta_{i2}P_{jt}^* + \beta_{i3}Z_{it} + \mu_{it} \quad (1)$$

where Y_{it} is the Area_{it} planted in the i th crop (or its total production Q_{it}) in time period t , P_{it}^* is the i th output expected price. P_{jt}^* ($j = 1..n$) (excluding i) are expected prices of other products in period (t), Z_{it} are other variables that have impact on cropped area or quantity produced, μ_{it} is a stochastic error term.

The function of expected prices P_{it}^* and P_{jt}^* are specified by the Nerlove distributed lag in Eq. (1) as follows:

$$P_{it}^* = P_{it-1}^* + \alpha_i(P_{it-1} - P_{it-1}^*) \quad (2)$$

$$P_{jt}^* = P_{jt-1}^* + \alpha_j(P_{jt-1} - P_{jt-1}^*) \quad (3)$$

where α_i and α_j are the expectation coefficients, or the elasticity of adjustment if surrogates for P_{it}^* and P_{jt}^* are in logarithms. Other variables are as defined previously.

The transformation of Eq. (1) in a supply response function that allows estimation of β parameters yields the following equation (assuming that α_i and $\alpha_j = \alpha$ since they pertain to the same farmers).

$$Y_{it} = \gamma_{i0} + \gamma_{i1}P_{i(t-1)} + \gamma_{i2}Y_{i(t-1)} + \gamma_{i3}P_{j(t-1)} + \gamma_{i4}Z_{it} + \gamma_{i5}Z_{i(t-1)} + V_{it} \quad (4)$$

($Y_{i(t-1)}$ is changed to $Q_{i(t-1)}$ in case of the quantity response function) where all variables as defined before and V_{it} is a random residual different from μ_{it} .

Estimated parameters (γ_i) of Eq. (4) will allow working out unknown β s parameters in Eq. (1) according to the following relationship:

$$\begin{aligned} \beta_{i0} &= \frac{\gamma_{i0}}{\alpha}; \beta_{i1} = \frac{\gamma_{i1}}{\alpha}, \beta_{i2} = \frac{\gamma_{i3}}{\alpha}, \beta_{i3} = \gamma_{i4}, \alpha \\ &= (1 - \gamma_{i2}) \text{ and } V_{it} = [\mu_t + (1 - \alpha)\mu_{t-1}] \end{aligned}$$

In this study the maximum likelihood estimation is used via Autoreg Procedure in SAS (1988). The (ML) estimators will be consistent and asymptotically efficient under the assumption of independence of the model errors V_{it} .

5. Results

The econometric model developed in Eq. (4) was applied to selected vegetables in Oman, namely, onion, garlic, sweet melon, watermelon, cucumber, tomato, pepper and potato, cabbage and okra. Single equations for planted acreage or total quantity produced were fitted using SAS Autoreg for standard maximum likelihood procedure and tested for partial and overall significance (SAS, 1988). All variables are measured in logarithmic forms; therefore, parameters' estimates are elasticities.

Data used included per crop acreage planted production, prices and export quantity for the period 1982–1995. Quantities are measured as the total annual quantity harvested and sold by all farmers provided by two sources (JICA, 1990; MOAF, 1990–1995). Prices are measured as the deflated

values of mean prices paid by consumers available at the Ministry of Development (MOD, 1995). The deflator used for all prices was consumer price index provided in Central Bank of Oman reports (CBO, 1980–1995). Planted areas are measured in hectares and represent crop aggregate planted areas for the country. The choice of other crops to be included in the supply response equation was based on the cross-price effects indicated in Table 1. Due to limited time series only prices of the two most competing crops are included in the estimation process. The least significant were then deleted.

Parameter estimates of the supply response functions are reported in Table 2. With the exception of sweet melon, okra and garlic, all parameters γ_{j1} are significant with expected signs at less than the 10% level suggesting a strong short-run response to prices. Acreage price response for sweet melon and okra is significant at about 30% level. Garlic acreage is negatively related to price suggesting a back binding supply curve. This could be explained by the prevailing high prices of locally-produced garlic. Local garlic, among a few other commodities, is surprisingly very expensive compared to imported garlic. Higher prices have attracted more acreage in garlic production although prices have been decreasing. Parameter estimates γ_{i3} are all significant at less than the 5–10% level confirming the relevance of other product prices in supply–response equations. Field crop area significantly affects onion and okra supply response. Likewise exported quantities of tomatoes and sweet melon are significant factors in supply response equations of tomatoes and sweet melon.

Supply response functions specified in Eq. (1) are derived from the estimated supply equations and presented in Appendix A. Their parameters, β_{it} s and the adjustment coefficients are given in Table 3. The adjustments coefficient (α_i) expressing the elasticity of expectations in this case, range from 0.177 to 0.812. With the exception of garlic, cabbage and okra, the coefficient of adjustment is statistically equal at the 15% significance level. Therefore, the hypothesis used earlier that coefficients of adjustments are all equal is accepted for most common vegetable crops. These coefficients suggest that under current production and marketing conditions it will need vegetable growers of most common crops in Oman 2 to 6 years for 95% expectation adjustments. Farmers are able to make

Table 2

Maximum likelihood estimated supply response functions in Area_{it} or $\ln Q_{it}$

Crops	Intercept	ln (own price) lagged	ln (Area/Q lagged)	ln (other product prices)		ln (field crop area)	ln (field crop area lagged)	ln (export quantity)	ln (export quantity lagged)
	γ_0	γ_1	γ_2	γ_{3-1}	γ_{3-2}	γ_4	γ_5	γ_6	γ_7
Tomato	3.827 (3.709)	1.111 (3.821)	0.381 (1.896)	–0.923 (–2.904) (Watermelon)				–0.088 (–1.355)	0.125 (1.892)
Onion ^a	6.549 (2.847)	0.132 (1.520)	0.188 (5.294)			0.348 (–1.615)	–0.576 (–2.093)		
Pepper	6.104 (1.887)	1.067 (2.337)	–0.245 (–0.405)	–0.546 (–2.131) (Onion)					
Watermelon ^b	1.712 (1.120)	0.337 (1.924)	0.639 (2.806)	–0.337 (–1.924) (Pepper)					
Garlic ^a	2.266 (2.458)	–1.240 (–1.640)	0.700 (1.866)	–1.974 (–2.436) (Tomato)					
Potato	0.550 (0.974)	0.867 (1.901)	0.317 (1.805)	–0.403 (–1.525)	–3.228 (Garlic)	(–3.542)(Tomato)			
Cucumber	4.851 (2.263)	3.440 (2.503)	0.262 (0.952)	–1.127 (–1.280) (Watermelon)					
Sweet melon	3.572 (1.897)	0.343 (0.973)	0.478 (1.507)	–0.289 (–0.827)	–0.074 (Watermelon)	(1.312) (Onion)			
Cabbage	1.778 (1.105)	1.142 (2.210)	0.811 (4.064)	–26.77 (–1.175) (Sweet melon)	–2.100 (–1.412) (Watermelon)				
Okra	10.847 (2.175)	2.095 (0.988)	0.823 (3.303)	–1.455 (–1.740) (Cabbage)		1.630 (–1.422)	0.064 (1.291)		

^a Supply responses for these crops are production responses, others are acreage response.Figures in parenthesis are *t*-values.^b Watermelon supply response is a production response in the form of $Y_t = \gamma_0 + \gamma_1(\text{Lagged price of melon}) + \gamma_2 Y_{t-1}$

Table 3

Parameters of specified supply response functions

$$Y_{it} = \beta_{i0} + \beta_{it}P_{it}^* + P_{2j}P_{jt}^* + \beta_{3i}Z_{it} + \mu_{it}$$

Crops	Intercept β_0	$P_{it}^*\beta_1$	$P_{1it}^*\beta_{1-2}$	$P_{2it}^*\beta_{2-2}$	$Z_{it}\beta_3$	α
Tomato	6.183	1.795	–1.491 (Watermelon)		0.202 (Export Q)	0.619
Onion	8.065	0.163	–	–	–0.429 (Field crop area)	0.812
Pepper	8.085	1.387	–0.723 (Onion)	–	–	0.753
Watermelon	4.742	0.934	–0.934 (Pepper)	–	–	0.361
Garlic	8.867	–4.133	–6.58 (Tomato)	–	–	0.300
Potato	0.805	1.269	–0.590 (Garlic)	–4.726 (Tomato)	–	0.680
Cucumber	6.573	4.661	–1.527 (Watermelon)	–	–	0.738
Sweet melon	6.843	0.657	–0.540 (Watermelon)	–0.950 (Onion)	0.142 (Export Q)	0.520
Cabbage	9.407	6.206	–14.164 (Sweet melon)	–11.111 (Watermelon)	–	0.189
Okra	61.282	11.819	–8.220 (Cabbage)	–	–9.209 (Field crop area)	0.177

reasonable price expectations with a lower error each year. This short adjustment period of time is more likely a result of low price fluctuations of fresh vegetables in Oman.

Short- and long-run supply price elasticities are given respectively by parameters γ_{1s} and β_{1s} (Tables 2 and 3). Short-run supply response to prices is rather low for all vegetables except cucumber and okra. It ranges from 0.132 for onion to 3.440 for cucumber. The long-run response, however, is greater than the short-run response and greater than one for all crops except onion, watermelon and sweet melon. Onion has the lowest long-run price supply response of 0.163 followed by sweet melon (0.657) and watermelon (0.934) okra, cabbage, cucumber and garlic have the highest long-run elasticity ranging from 4 to more than 11. Tomato, pepper and potato supply response is moderately elastic ranging from 1.3 to 1.8 approximately.

Low short- and long-run elasticities of supply indicate that growers of all these crops do not make significant short- and long-run acreage/production adjustments in response to changes expected prices. This may be due to price sustainability over time and the emergence of other supply determinants more relevant than prices. Reliable market outlets are among these factors. Vegetable growers in Oman have indicated that they were willing to sacrifice higher prices for a more sustainable and strong marketing system (Omezzine, 1997). They believe a strong, integrated vegetable market will result in rewarding

prices and higher response to price. On the other hand, high price elasticity of supply may indicate that prices are significant factors determining acreage or production of vegetable crops.

Supply response functions of all crops except onion have included prices of other crops as determinants of acreage or quantity produced. Parameters γ_{j3} are short-run cross-elasticities and β_{j2} are long-run cross-elasticities. Short- and long-run cross-elasticities have ranged from elastic to inelastic indicating low and high supply adjustments to expected prices of other products.

Results show that tomato is a serious competitor for potato and garlic in both short- and long-run. On average a sustainable 1% change in price of tomatoes will induce more than 4% and 6% opposite changes in the acreage of potato and garlic, respectively.

Watermelon is a significant competitor for tomato, cucumber, sweet melon, and cabbage in both short- and long-run. In the long-run a 1% decrease in watermelon price will result in increased acreage of tomato, cucumber, sweet melon and cabbage by respectively 0.923%, 1.5%, 0.54% and 11.11%, respectively.

Supply response of pepper is significantly affected by expected prices of okra in both long- and short-run. A 1% change in the price of okra results in more than 6% opposite change in the area of pepper. Onion, garlic and pepper also have a significant price cross-effect on other vegetable acreage or production with low cross-elasticities.

Other factors affecting supply and vegetable crops are areas of field crops and exports. Okra and onion acreage have shown response to changes in areas of field crop. Exported quantity variable was significant only in the tomato equation.

6. Conclusion

This study investigated short- and long-run vegetable supply response to prices and other factors in Oman. It sheds some light on growers' behavior and their price expectation process. The methodology used incorporated the adoptive expectation model in supply response functions for selected vegetables.

Results show that vegetable growers adjust relatively fast to changes in expected prices. This short adjustment period may be an explicit result of low price fluctuation of vegetables in local markets. Short- and long-run price elasticities were low for a few crops suggesting price sustainability and the emergence of other supply determinants indicating significant acreage/production adjustments based on expected prices. Growers' crop-mix and production decision in general are based to a great extent on cross-response between crops. Expected prices of other product competitors for farm space were in most cases important in specifying supply response equations. Cross-elasticities ranged from low to high indicating a significant supply adjustment to prices of other products.

In general these results show evidence of positive supply response to prices for most vegetable crops in Oman. They provide significant information and valuable insights for crop enhancement programs and market development. Efforts aimed at promoting sustainable marketing outlets and promoting high value, high quality products for export require an understanding of farmers' responses to prices.

Appendix A

Supply response functions

Tomato area	$6.183 + 1.795 \ln PT_t^* - 1.491 \ln PWM_t^* + 0.202 \ln TEXT_t$
Onion production	$8.065 + 0.163 \ln PON_t^* - 0.429 \ln FCA_t$

Pepper area	$8.085 + 1.387 \ln PPP_t^* - 0.723 \ln PON_t^* - 8.799 \ln POK_t^*$
Cucumber area	$6.573 + 4.66 \ln PPP_t^* - 1.527 \ln PWM_t^*$
Sweet melon area	$6.843 + 0.657 \ln PSM_t^* - 0.540 \ln PWM_t^* - 0.95 \ln PON_t^* + 0.142 \ln SM EXP_t$
Garlic production	$8.867 - 4.133 \ln PGC_t^* - 6.58 \ln PT_t^*$
Potato area	$0.805 + 1.269 \ln PPT_t^* - 0.590 \ln PGC_t^* - 4.726 \ln PT_t^*$
Cabbage area	$9.407 + 6.206 \ln PCB_t^* - 14.164 \ln PSM_t^* - 11.111 \ln PWM_t^*$
Okra area	$62.282 + 11.819 \ln POK_t^* - 8.220 \ln PCB_t^* - 9.209 \ln FCA_t$
where FC_t	Total area of field crop in year t .
PCU_t^*	Expected price of cucumber in period t .
PGC_t^*	Expected price of garlic in period t .
POK_t^*	Expected price of okra in period t .
PON_t^*	Expected price of onion in period t .
PPP_t^*	Expected price of pepper in period t .
PPT_t^*	Expected price of potato in period t .
PSM_t^*	Expected price of sweet melon in period t .
PT_t^*	Expected price of tomato in period t .
PWM_t^*	Expected price of watermelon in period t .
$TEXT_t$	Tomato exported quantity.
$SMEPT$	Sweet melon exported quantity.

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