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Demand Analysis of Selected Fruits and Vegetables in Oman

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تحليل دالة الطلب على بعض منتجات الفاكهة والخضر في سلطنة عمان

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خلاصة: لسلوك المستهلكين، والتغييرات المتوقعة على طلب المنتجات الغذائية، تأثيرات معنوية على قرارات الإنتاج والتوزيع. كما أن لاستجابة المستهلكين للتغيرات في الأسعار والدخل والمحددات الأخرى لدالة الطلب، أهمية كبيرة لدى أصحاب القرار في مجالات الإنتاج والتسويق. تقوم الدراسة الحالية بتقدير الاستجابة لدالة الطلب على بعض الفاكهة والخضر المختارة في سلطنة عمان باستخدام الإحصائيات القومية التراكمية. وتهدف الدراسة إلى توفير المعلومات المطلوبة لاتخاذ القرارات العامة والخاصة. ولقد دلت النتائج على أن معظم مستهلكي الفاكهة والخضر يستجيبون لتغييرات الأسعار بصورة متوقعة. وتختلف الاستجابة من مجتمعات إلى أخرى اعتمادا على طبيعة وأهمية المنتجات في السلوك الغذائي للمستهلك. وفي حالات قليلة فقط لم يكن الدخل هو الذي يحدد الطلب. كما أن كثيراً من الفواكه والخضر وات تحل بعضها محل الآخر أو تكملها في الوجبة الغذائية العمانية. ولهذه النتائج فوائد كثيرة للمزارعين والموزعين، تمكنهم من ضبط الإنتاج والتوزيع بناءً على استجابة المستهلك.

ABSTRACT: Consumer behavior and prospective changes in demand of food products have a significant impact on production and distribution decisions. Consumer responsiveness to changes in prices, income and other demand determinants is very important to production and market decision-makers. The present study estimates demand responses for selected fruits and vegetables in Oman using consumer aggregated national data. The main objective is to generate information needed for making public as well as private decisions. Results indicate that most fruit and vegetable consumers respond to price and income changes in the expected manner. Responses are different from one commodity to another depending on its nature and importance in the consumer's diet habits. In a few cases income is not a significant determinant of the demand. Moreover, many fruits and vegetables have shown a relationship of substitution and complementarity consistent with the Omani diet. These results are useful to farmers and distributors to allow them to adjust their production and marketing services according to the consumer's response.

Fruits and vegetables have been important in the Omani diet. Per capita fruit and vegetable consumption in Oman has increased since the 1970's as a result of remarkable economic and social development that accelerated income growth and caused a substantial change in the diet of the population. Per capita consumption of vegetables and fruits in 1995 reached more than 100 kg and 90 kg, respectively (JICA, 1990; Anonymous, 1996 a & b). The growing demand for fruits and vegetables has been a source of interest to local producers, businessmen and the public sector. Decisions in production, marketing and consumption are significantly affected by consumers' behavior and changes in demand. Implicit to the formulation of these private and public decisions is information about consumer demand and its determinants. Demand analysis has been used extensively in price forecasting and outlook analysis. It can generate information on demand elasticities that are important to decision makers and the private sector. Consumer demand theory suggests variables that influence consumer purchasing behavior (Deaton and Muellbauer, 1980; Phlips, 1974; Shenggen *et al*, 1995). Demand analysis has significant influence on the formulation of public policy with respect to farm price programs, subsidies, and market development. It is also frequently used by businesses in their management and output decisions. The most important information to market decision makers is responsiveness of consumers to changes in prices and income. These cause and effect variables are most important in explaining consumer behavior. This study estimates relevant consumer parameters for fruit and vegetable demand in Oman. First, key determinants of fruit and vegetable demand are identified, with primary emphasis on prices and income. Then demand theory is used to specify relevant variables for statistical estimation of consumer demand equations for selected fruit and vegetables. The methodology draws on prior information of markets for each commodity. Time-series data is then used to

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statistically estimate the demand variables.

Modeling Fruit and Vegetable Demand

THEORETICAL BACKGROUND AND APPROACHES TO DEMAND ANALYSIS: Market demand is an important component of the price determination process. It is defined as the schedule of the alternative quantity of a product that all consumers are willing and able to buy as the price varies. All other factors are held constant. In final product markets, the quantities that consumers will buy at different prices are a function of many factors. These variables include (1) the price of the commodity, (2) prices of other products which are substitutes or complements in consumption, (3) consumers' income, (4) other variables such as consumer taste and preferences, diet habits, social variables (Phlips, 1974; Ritson, 1977). The functional notation of the demand function is symbolically expressed as follows:

$$Q_x = f\ (P_x,\ P_s,\ P_c,\ I,\ P_o,\ M) \qquad (1)$$

where Q_x is the quantity demanded of a commodity X, P_x is the price of X, P_s is the price of substitutes to X, P_c is the price of complements of X, I is consumer income, P_o is the population size in the market, and M is a set of all other variables that may have an effect on Q_x.

The theoretical design of demand for any single commodity or for a group of commodities can be separated into static and dynamic demand systems. In a static demand system, consumers are assumed to adjust instantaneously to a new equilibrium resulting from changes in prices or income. An adjustment process is not observed. This assumption is restrictive in that it ignores adjustments that occur throughout time due essentially to habit formation and purchase of durable goods (Johnson et al, 1983). Dynamic demand functions overcome these deficiencies, but have the drawback of being difficult to estimate empirically. Johnson and his co-workers (1983) recommended three approaches for estimating dynamic demand systems. Firstly, trend variables can be added to the static demand function. Secondly, a dynamic utility function can be used to derive the demand function, and thirdly, both past and future considerations can be integrated into a more coherent treatment of the consumer choice problem.

Empirical measures of demand follow one of two approaches. The consumer utility function and constrained maximization can be used to derive demand equations. More commonly, direct specification of demand equations can be used in conjunction with market information and demand theory. The first approach requires specification of a utility function. The utility function is maximized subject to the consumer's budget constraint, providing a demand function for all consumed products and services from first order condition equations. To obtain a solution, individual utility functions must be consistent with the basic axioms of ordinal utility theory and consequently must be differentiable. Specifically if the utility function is as follows:

$$U = u\ (X_i) \qquad (2)$$

and the budget constraint is:

$$I = \sum_{i=1}^{n} P_i\ X_i \qquad i = 1,2,\ldots\ldots n \qquad (3)$$

where X_i is a finite number of measurable commodity bundles, I is consumer income, and P_i is the price of the commodity X in the bundle. Demand functions for the commodities are obtained by solving the n+1 first order conditions, given that the Hessian matrix of partial derivatives is positive. The demand functions Q_i for commodities X_i are homogeneous of degree zero in prices and income, and have the following form:

$$Q_i = f\ (P_i,\ I) \qquad i = 1,2,\ldots\ldots n \qquad (4)$$

These demand equations are subject to several restrictions (Phlips, 1974; Johnson et al, 1983; Fox, 1992), namely homogeneity, Engel aggregation, symmetry, and Cournot aggregation conditions. It is also necessary to assume weak separability of utility functions to estimate specific demand equations for particular food commodities (Blackorby, *et al,* 1978; Alston and Chalfant, 1987; Giancarlo, *et al,* 1994).

Price, income and cross-elasticities of demand can be shown in a demand matrix constructed by totally differentiating the demand equations Q_i. The demand matrix takes the form:

$$[A] = [E]\ [P] \qquad (5)$$

Where A is the matrix of the first derivatives of the demand equations Q_i divided by Q_i. Matrix E has n (n + 1) elements. The matrix E includes n own price elasticities representing all commodities in the bundle and n(n - 1) and n cross and income elasticities, respectively (Kamien, 1964). Matrix P represents first derivatives of prices (P_i) divided by P_i.

The utility function approach may yield mathematically intractable demand functions that cannot be empirically estimated (Phlips, 1974). A more practical approach is to use directly specified demand functions which rely on utility theory to suggest relevant parameters. This method has been widely used in empirical demand estimation (Gardiner and Dixit, 1987; Duffy *et al,* 1990; Thurman, 1987). The direct demand approach draws heavily on prior information on the commodity. Its statistical estimation emerges from a hypothetical *a priori* model specified on the basis of observed information about consumption patterns and theoretical factors that may have significant effects on demand for a particular commodity.

Another consideration is whether to estimate a product demand equation separately or in a system of demand equations. Demand estimation studies have used single quantity dependent models (Lindstrom and King, 1956; Waugh, 1964; Castro and Simmons, 1974; Shuffit, 1954). The single equation model is the easiest to estimate given market data constraints and problems with price collinearity. Fox (1992) states that the single equation approach can be used when all of the product moves through a single outlet and when the quantity sold is determined mainly by economic factors operating prior to the marketing season. Interdependent systems are advocated to estimate demand and supply functions in cases where economic data are generated by systems of relations that are, in general, stochastic, dynamic and simultaneous (Marschak, 1950). Under those circumstances, the determination of demand evolves from the solution of the whole system and not as a single equation estimation (Jesse and Machado, 1976; Mittlehamer, 1980; Clevenger and Snelly, 1974; Zeep, 1981; Guetierrez, 1983).

MODEL SPECIFICATION AND ESTIMATION PROCEDURE: Theoretical demand variables (i.e. quantities consumed, prices, and income) can be observed through published market data. Once a functional form for the demand equation has been specified, demand parameters can be statistically estimated. The estimated parameters are used to derive price and income elasticities.

For agricultural commodities, demand is typically less variable than supply, therefore market observations on prices and quantities should map out a demand curve. If demand were more variable than supply, it would be likely that observations on prices and quantities would map out a supply curve. For fruits and vegetables in Oman, supply is significantly more variable than demand due to weather and pests. Fruits and vegetables have been a fairly constant portion of consumer dietary requirements, with some changes in variety and a rising trend in per capita demand as incomes have risen over the last 20 years. In our study, the observed market prices and quantities are assumed to represent demand relationships for fruits and vegetables in Oman.

Consumer demand for a product is influenced by product price, prices of substitute products, prices of complementary products, and consumer income. Market demand is also influenced by total population, as market demand is derived from the horizontal summation of individual consumer demand equations. Population can be approximated by using per capita income. Theoretical market demand equations for fruits and vegetables in Oman include their own prices, prices of substitutes, complements, and per capita Gross National Product (GNP) as a measure of income.

Consumer Demand Theory predicts an inverse relationship between price and quantity demanded. For a particular variety of fruit, for example the watermelon, as the price of watermelon goes up, the market demand will fall. The expected sign on the estimated price parameter is negative. Demand for watermelon is also influenced by the prices of substitute fruits. For example, an increase in the price of grapes may result in an increase in demand for watermelon as consumers chose the relatively less expensive watermelon. The expected sign on the substitute fruit parameter is positive. Goods consumed together have a negative relationship between the price of the complement and the quantity demanded. For example, Omanis consume cream with fruit cocktail. An increase in the price of cream should cause a decrease in demand for fruit cocktail. Changes in income will also affect watermelon demand. Depending on the nature of the product, a rise in income may increase or decrease the products' demand. It is unlikely that watermelon is an inferior product in Oman, therefore we anticipate that the income response would be positive. However, the positive response may be small (necessity) or large (luxury), depending on the level of the consumer's income.

For higher income consumers, watermelon may be a necessity, which implies, for example, a 1.00% increase in income will cause a less than 1.00% increase in demand. However, for low and middle income families, watermelon may be a luxury, which means that a 1.00% increase in income will cause a more than 1.00% increase in demand. The traditional Omani diet includes a large number of vegetable dishes, using a variety of vegetables, primarily tomatoes, squash, onions, and potatoes. Fruits are offered as a side dish or dessert. Fruits are more likely to be luxury goods than vegetables in the typical Omani household. How responsive fruit and vegetable consumers are to changes in income is especially relevant for producers and marketers in Oman, since the country is undergoing rapid economic growth. Finally, changes in population will change market demand for fruit and vegetables. Oman is experiencing a high growth rate in both native population and foreign nationals. It has been projected that the current population of approximately 2 million may double within 20 years.

Demand can also be estimated for aggregate fruits and total vegetables. Aggregate fruit and vegetable prices are anticipated to be less elastic than those for specific fruits and vegetables. For specific fruits and vegetables, there are more substitute goods, making consumer responses to prices more flexible.

For the present analysis, we assumed that purchase decisions on fruits and vegetables can be separated from purchase decisions on other commodity bundles by imposing weak separability on the utility function (Blackorby et. al., 1978). It is also necessary to assume that all income allocated for fruits and vegetables is spent. There is no *a priori* reason to believe that a system is required for estimation of fruit and vegetable demand, therefore the single equation approach is used.

Market demand equations were specified for selected fruits and vegetables. The general form of the demand functions is hypothesized as follows:

$$Q_i = a_0 + a_1 P_i + a_2 P_s + a_3 P_c + a_4 I + a_5 T + e \qquad (6)$$

where Q_i is the quantity demanded of the *ith* commodity, P_i is the purchase price of the *ith* commodity, P_s is the price of substitute products P_c is the price of the complement product, I is the per capita income of consumers, T is a trend variable to account for unspecified explanatory variables that may have significant effects on Q_i, and e is a stochastic error term.

Data for the period 1982 to 1995 was fitted to the equations in the model. Annual data on quantities of fruits and vegetables purchased (tonnes) and retail prices (rials per kg) were obtained from the Ministry of Development. Disposable income and population data were obtained from various issues of the Statistical Yearbook of Oman. Prices and income were deflated by a fruit and vegetable consumer price index provided by the Central Bank of Oman. The demand functions of fresh vegetables and fruits were fitted as single equations by Ordinary Least Squares (OLS) using the SAS Statistical Package. Each equation was tested for partial and overall significance through student's *t* and *F-tests*. The Durbin Watson statistic was used to test for serial correlation (SAS, 1988).

Results

Results from OLS regressions based on the specified model of Equation 6 are presented in Tables 1 and 2. Most R^2 values were greater than 0.70 for fruits and vegetables with the exception of onions, potatoes and watermelon which were between 0.60 and 0.69. R^2 for sweetmelon and cucumber was less than 0.60 indicating a weak overall significance of both models. R^2 values for all fruit and date equations were less than 0.20 indicating that they were not significant. No statistical inference can be made out of these equations. Due to the log linear estimation, parameters for product price, income and prices of other products are direct measures of price, income and cross elasticities of demand, respectively.

Table 1 indicates that all of the own-price elasticities have the expected negative coefficient. All own-price coefficients are statistically significant, with the exception of the cucumber model. The cucumber demand equation had the lowest adjusted R^2 and may suffer from misspecification, which would account for the non-significant own-price coefficient. Demand elasticities for onions and peppers are less than 1.00%. A decrease in price will result in a less than proportionate increase in consumption. Typically, food prices are inelastic. However, for tomato, potato and cabbage a change in price is associated with a more than proportionate change in the quantity demanded. These results are not totally in accordance with normal food products response in developed nations. However, Oman is a developing nation with strong cultural traditions which can influence food demand response and make demands for traditional food products more inelastic.

Demand price elasticity of all vegetables is about equal to one. Demand for all vegetables was found to be less elastic than demand for most individual vegetables, with the exception of onion and pepper. These results are consistent with a general empirical characteristic indicating that the demand for a product is more elastic the more substitutes it has.

Income coefficients were significant only for onions, tomatoes and potatoes at more than 0.15 level. Demand for cabbage, pepper, and cucumber was not responsive to income change. For tomatoes, income elasticity, log (GDP/C) was positive and less than one suggesting they are necessity goods. A 1.00% increase in income will result in a less than 1.00% increase in quantity demanded. This result is consistent with Engel's law for normal goods. Onions and tomatoes are a staple part of the Omani diet, being included in most of the traditional dishes. Therefore the estimated coefficients are consistent with prior expectations. Potato income elasticity is significantly

TABLE 1

Statistical results for selected vegetables

Commodity	Intercept	Log Own Price	Log Per Capita Income	Log Prices of Other Products	R^2
Onion	-11.66	0.73	0.61	-1.12	0.69
	(-1.25)	(-2.69)	(0.48)	(-1.40)	
				Tomato	
Tomato	-10.72	-1.37	0.60	-0.40	0.81
	(-1.88)	(-3.05)	(0.84)	(-2.58)	
				Onion	
Potato	-30.86	-1.923	2.69	-2.12	0.64
	(-1.77)	(-1.18)	(1.29)	(-3.00)	
				Cabbage	
Cabbage	-2.79	-2.62		4.04	0.70
	(-5.79)	(-3.58)		(4.73)	
				Tomato	
Pepper	-5.77	-0.41		0.79	0.76
	(-30.72)	(-1.68)		(2.16)	
				Tomato	
				-0.69	
				(-3.66)	
				Cabbage	
Cucumber	-2.43	1.83		4.00	0.57
	(-2.07)	(-0.94)		(3.27)	
				Tomato	
				-0.57	
				(-1.40)	
				Onion	
All Vegetables	-6.57	-1.05	0.35		0.59
	(-1.27)	(-3.77)	(0.53)		

Values in parentheses are student's t-statistics.

greater than one, suggesting that potatoes are a luxury good in the Omani diet. Consumers will tend to substitute potatoes for other staple foodstuffs when income rises. This has implications for the overall consumption of potatoes as Omani national income continues to rise. For example, a 1.00% increase in income will result in a 2.70% increase in potato demand. Increases in demand will put upward pressure on potato prices, signaling farmers to increase production of potatoes to meet the increase in demand.

For all vegetable products, the equations had significant coefficients for prices of related goods, either substitutes, complements or both. Tomatoes were a significant complement to onions but a substitute to cabbage, pepper, and cucumber. Onions were a complement to tomatoes and cucumbers while cabbage was a complement to potatoes and peppers. Demand for onion will decrease by 1.12% for an increase in price of tomatoes of 1.00% and vice versa. Demand for cabbage, pepper and cucumber will decrease by 4.04%, 0.79% and 4.00% respectively, if the tomato price decreases by 1.00% and vice versa. These relationships between quantity demanded of one product and the price of another product may be consistent with Omani dietary habits as vegetables are traditionally consumed together in salads. However, the simple interpretation of positive cross-price elasticities as substitute products and negative cross-price elasticities as complement products may be misleading as it ignores the income effect of any price change. An increase in the price of one commodity will force consumers to reduce their purchases of all commodities as a result of a decrease in real purchasing power. The income effect of a price increase will reduce demand for all commodities. However, the substitution effect of a price increase will increase demand for a substitute product and decrease the demand for a complementary product. Thus, for complementary products, the substitution and income effects work in the same direction, while for substitute products they move in opposite directions.

The coefficients on prices of other products correspond to the cross-price elasticities. The onion model shows tomatoes as a complement since tomato

TABLE 2

Statistical results for selected fruits

Commodity	Intercept	Log Own Price	Log Per Capita Income	Log Prices of Other Products	Trend	R^2
Sweet melon	-8.50	-1.31	0.45	1.11		0.43
	(-0.82)	(-2.24)	(0.36)	(0.90) Banana		
Orange	-11.92	-1.09	0.85	0.30		0.94
	(-3.15)	(-10.90)	(1.73)	(1.57) Lemon		
Apple	-18.86	-0.92	1.50	-1.46		0.92
	(-3.59)	(-9.39)	(2.34)	(-2.22) Banana		
Grapes	-78.02	-0.82	0.47	-1.24	0.03	0.93
	(-3.68)	(-6.53)	(1.09)	(-2.67) Banana	(3.37)	
Banana	-10.62	-1.12	0.77	0.82		0.75
	(-1.68)	(-1.34)	(1.00)	(4.01) Pepper		
Watermelon	-7.00	-0.31	0.25	-0.55		0.66
	(-2.04)	(-1.53)	(0.59)	(-1.95) Sweet Melon		
Dates	0	-0.31	-0.40			0.15
		(-1.21)	(-1.01)			
All Fruits	-5.69	-0.56	0.39			0.19
	(-0.87)	(-1.25)	(-0.46)			

Values in parentheses are student's t-statistics.

price has a negative relationship with onion demand. The estimated coefficient of -1.12 was significant and negative, suggesting that for his onion consumption the Omani consumer requires tomatoes (Table 1). Likewise, onion was found to be a complement to tomatoes. The onion price coefficient was also statistically significant in the tomato demand equation. Cabbage price was statistically significant with a negative coefficient in potato demand suggesting cabbage as a complement to potatoes. A 1.00% decrease in the price of cabbages will result in a 2.00% increase in quantity demanded of potatoes. Cabbage was also a complement to pepper. The coefficient of -0.69% suggests that a 1.00% decrease in the price of cabbage would result in a less than 1.00% increase in quantity demanded of peppers. However, the tomato price cross elasticity of demand suggests that tomatoes elasticity was 0.79% for tomato prices in the pepper demand equation. Tomatoes are substitutes for cucumbers as well. For a 1.00% decrease in the price of tomatoes, the quantity demanded of cucumbers should fall by 4.00%. This is a surprising result, considering that the traditional Omani salad contains cucumbers and tomatoes, one would expect tomatoes to be a complement for cucumbers.

Table 2 lists estimated demand parameters for fruits. All the own-price elasticity estimates, represented by the coefficients on the price variables, had the expected negative sign. All own-price elasticities were statistically significant at least at the 5.00% level except for bananas and watermelon. Demand was elastic for apples, sweet melons, and bananas. The price elasticities of demand for apples, grapes, and watermelon was less than one, indicating that a 1.00% change in the price of these commodities would result in a less than 1.00% change in their respective quantities. Demand for watermelon was however, the most inelastic, suggesting that watermelon has no or very few substitutes. Price elasticities of demand for oranges, sweet melons and bananas were greater than one indicating that consumers are more responsive to price changes in these commodities. This may be due to the large number of substitutes available for these products.

Price elasticity of all fruit demands was equal to 0.56% and lower than demand elasticities for individual fruits. Although this result was consistent with the basic characteristics of lower demand price elasticity of products with few substitutes, the whole equation for all fruits was not statistically significant as R^2 was very low and t values for parameters were low.

Income was statistically significant in the demand equations for oranges and apples. Oranges are suggested to be necessity goods in the Omani diet with an income elasticity of less than one. The income elasticity for apples suggests a luxury product, with a 1.00% increase in income resulting in a 1.50% increase in quantity demanded. This has implications for Omani expenditures on food products, especially the share of imports in the food bill. Oranges and apples are imported products. As the national income grows, demand for imported fruits will also grow. This has implications for food importing businesses and for government policies on inspecting and regulating fruit imports. Identifying relationships between domestically produced fruits and imported fruits is very important for the allocation of limited domestic agricultural resources. Bananas, for example, are an important income source in the southern region of Oman. Estimating the consumer response to changes in banana prices and consumption of imported substitute fruits such as apples and grapes, is important for predicting revenue changes for domestic banana farmers, as well as for predicting import demand during the off-season.

Cross price elasticities for fruits were obtained from the estimated coefficients on other prices. The sweet melon price was statistically significant in the watermelon demand equation. The negative coefficient suggests that sweet melons were complements to watermelon. A 1.00% decrease in the price of sweet melon should result in a 0.50% increase in the quantity demanded of watermelon. Banana price was statistically significant in the demand equations for sweet melon, apples, and grapes. For apples and grapes, the banana price coefficient was negative, suggesting a complementary relationship. A decrease in the price of bananas of 1.00% would result in a 1.50% and 1.20% increase in the quantity of apples and grapes consumed, respectively. Lemon price was statistically significant in the orange demand equation. The estimated cross-elasticity was positive, suggesting a substitution relationship between oranges and lemons. A 1.00% decrease in the price of lemons will result in a 0.30% decrease in the quantity demanded of oranges. In a year with a good domestic lemon harvest, this would suggest that lower lemon prices would reduce the demand for imported oranges. Grape price in the banana demand equation was significant and suggests a substitution relationship between the consumption of grapes and bananas. A 1.00% change in grape prices will result in 0.80% change in consumption of bananas.

Results for date palm fruits were not statistically significant. The non-significant parameters suggest that the model may be misspecified. However, without prior information on date consumption patterns in Oman it is not possible to develop an alternative demand function for dates. The results emerging from an analysis of national data indicate that date demand is not significantly influenced by changes in income. As dates are an extremely important food in social and cultural events in Omani society, it is not surprising that the estimated income parameter of −0.40 was statistically equal to zero. Thus a change in national income should not significantly influence the demand for dates.

Conclusions

This study estimated Omani consumer demand response to changes in product price, complimentary and substitute product prices, and consumer incomes. The results showed the expected signs for own-price elasticities, cross-price elasticities and most income elasticity estimates. In a few cases the response to income changes were not significant indicating no long-run shifts in demand due to income variation. In these particular cases demand was not income dependent. In general, the results of this study represent an important first step in examining consumer demand for agricultural produce in Oman. For fruit demand, it was especially relevant for examining dependence on imported commodities and the substitutability between domestic production and imports. Approximately 70.0% of Omani agricultural land is planted with fruit trees. Consumer responsiveness to fruit prices has major implications for farm revenue in Oman. Estimates of consumer responsiveness to changes in commodity prices and incomes are essential for making any sound business decisions. Agricultural producers, distributors, and government policy-makers require information on response of consumers to changes in prices, trends in income, and population growth. Farm management decisions and investments in food processing require forecasts of food demand response. Anticipating demand changes in response to supply or international price shocks can be predicted if consumer responsiveness has been quantified.

References

Alston, J.M. and J.A. Chalfant, 1987. Weak Separability and a Test for the Specification of Income in Demand Models with an Application to the Demand for Meat in Australia. *Australian J. Agr. Econ.* 31:1-15.

Anonymous. 1996a. Unpublished data on fresh fruits and vegetables production in Oman. Dept. of Statistics. Ministry of Agriculture and Fisheries Wealth, Oman.

Anonymous. 1996b. Unpublished documents on fruit and vegetable consumption, prices, import and export. Dept. of Statistics. Ministry of Development, Oman.

Blackorby, C., D. Primont, and R. Russell. 1978. *Duality, separability, and functional structure: Theory and economic applications*. North-Holland: New York.

Castro, R. and R.L. Simmons. 1974. The demand for green peppers, cucumbers and cantaloupes in the winter seasons. *North Carolina State Univ. Econ. Res.* Rep. No. 27.

Clevenger, T. and W. Snelly. 1974. Interseasonal demand - supply relationships for lettuce. *Proc. Western Econ. Assoc. 47th Ann Meeting*. Moscow, Idaho.

Deaton, A. and J. Muellbauer. 1980. An almost ideal demand system. *Am. Econ. Rev. 70*: 312-26.

Duffy, P., M. Wolgenant, and J. Richardson. 1990. The elasticity of export demand for U.S. cotton. *Am. J. Agr. Econ.* 12:468-474.

Fox, K.A. 1992. Demand analysis, econometrics and policy models.[Selected writings edited by S.R. Johnson, J.K. Sengupta and E. Thorbecke]. *Iowa State University Press*. Ames, Iowa.

Gardiner, W. and C. Carter. 1988. *Issues associated with elasticities in International Agricultural Trade. Elasticities in International Agricultural Trade*. Westview Press.

Gardiner, W. and P. Dixit. 1987. Price elasticity of export demand. *U.S. Dept. of Agr., ERS, FAER No. 228*. Washington, DC.

Giancarlo Moschini, Daniele Moro and Richard Green. 1994. Maintaining and Testing Separability in Demand Systems. *Am. J. Agr. Econ.* 76: 61-73.

Guetierrez, N. 1983. Economic study of the winter vegetable export industry of Northwest Mexico. *Unpublished M.Sc. thesis*, University of Missouri, USA.

Japan International Cooperation Agency (JICA). 1990. The study of a master plan for agricultural development. Final Rept. Vol. 5.

Jesse, E. and M. Machado. 1976. Trends in production and marketing of California market tomatoes. *Univ. of Calif. Agr. Exp. Stat. Div. Agr. Sci.*, 75-BL/1871.

Johnson, S.R., Z.R. Hassan and R.D. Green. 1983. Demand systems estimation methods and applications. *Iowa State University Press*. Ames, Iowa.

Kamien, M. 1964. A note on complementarity and substitution. *Intl. Econ. Rev.* 5:221-227.

Lindstrom, A. and R.A. King. 1956. The demand for North Carolina slicing cucumbers and green peppers. *North Carolina State College. Ag. Econ. Inf. Ser. No. 49.*

Marschak, J. 1950. Introduction - statistical inference in dynamic economic models. T.C. Koopmans (Ed.) Cowles Comm. Res. Staff Mono. No. 10. John Wiley and Sons, New York

Mittelhammer, R. C. 1980. The estimation of domestic demand for salad vegetables using *a priori* information. Unpublished Ph.D. thesis. Washington State University. [Abstract from "Demand Relationship for Vegetables: A Review of Past Studies." C.F. Nuckton, California Exp. Station. Giannini Foundation Special Rept. 80-1, 1980].

Phlips, L. 1974. *Applied Consumption Analysis*. North Holland, New York.

Ritson, C. 1977. *Agr. Econ., Principles and Policies*. Westview Press: Boulder, Colorado.

Shenggen, F., E. J. Wailes and G. L. Cramer. 1995. Household Demand in Rural China. A Two Stage LES-AIDS Model. *Am. J. Agr. Econ.* 77. 54-62

Shuffit, M.D. 1954. The demand and price structure for selected vegetables. *USDA Tech. Bull.* No. 1105.

Statistical Analysis System (SAS). 1988. *SAS/ETS Users Guide*. SAS Institute. Cary, North Carolina.

Thurman, W. 1987. The poultry market: demand stability and industry structure. *Am. J. Agr. Econ.*, 69:30-37.

Waugh, F. 1964. Demand and price analysis: Some examples from agriculture. *Technical Bulletin* No. 1316, U.S. Dept. of Agr. Econ. Res. Serv.: Washington, DC.

Zeep, G. 1981. U.S. Winter fresh tomato price and quantity projections for 1985. *U.S. Dept. of Agr.* ESS-4.

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