Agrekon

VOL. 8 No. 4 OCTOBER, 1969

REQUIREMENTS FOR CONTRIBUTIONS

Articles in the field of agricultural economics, suitable for publication in the journal, will be welcomed.

Articles should have a maximum length of 10 folio pages (including tables, graphs, etc.), typed in double spacing. Contributions, in the language preferred by the writer, should be submitted in triplicate to the Editor, c/o Department of Agricultural Economics and Marketing, Pretoria, and should reach him at least one month prior to date of publication.

The Journal is obtainable from the distributors: "AGREKON", Private Bag 144, Pretoria.

The price is 25 cents per copy or R1 per annum, post free.

The dates of publication are January, April, July and October.

"AGREKON" is also published in Afrikaans.

Contents

The demand for apples in South Africa - a statistical analysis*

by

J.J. VOSLOO, National Productivity Institute,

and

J.A. GROENEWALD, University of Pretoria

INTRODUCTION

The apple is one of the most important varieties of deciduous fruit produced in South Africa, constituting over 60 per cent of the total volume, and over 50 per cent of the total value of South African deciduous fruit exports in 1966. Apple production in South Africa is, and has, moreover, been expanding rapidly. According to projections, the apple crops are expected to increase by over 300 per cent in the 17 year period between 1963 and 1980.[1]

The apple industry has traditionally been highly dependent on export markets for its earnings; in 1966 about 57 per cent of the apples produced in the three main producing areas - Elgin, Langkloof and Ceres - was exported.[2] Recent developments on the export markets - increased competition, the devaluation and instability of the Pound Sterling, increased use of cold storage and Britain's bid for Common Market membership - have been or are potentially unfavourable for the South African apple industry. Thus it becomes necessary to determine to what extent the South African market can replace the export markets without depressing prices unduly and to what extent increased cold storage can be used as a means of further expanding the South African market. For both these purposes, knowledge of the nature and elasticity of the South African consumers' demand for apples may be regarded as a prerequisite.

HYPOTHESES TESTED

In economic theory, demand for a product is reflected as a relationship between prices paid and quantities taken with everything else remaining equal - the well-known ceteris paribus assumptions. In econometric analysis, however, such assumptions cannot be made and disturbances in the ceteris paribus conditions have to be catered for by examining the effects on demand conditions of variables which may, when varied, disturb these ceteris paribus conditions.

In the present analysis, the price of apples was thus assumed to be a function of the following variables:

1. Quantities of apples, according to the law of demand.
2. Time of the year, since the demand for apples may reasonably be expected to vary from season to season due to climatic conditions, etc.
3. Availability of other fruit. Two other fruits were considered: pears, which are often regarded as a close substitute for apples, since they are botanically similar, and are harvested at approximately the same time of the year, and oranges, on the strength of American findings that oranges did, in fact, compete with apples on the consumers' market.[3]
4. Prices in the previous period. This variable was included because consumption in various periods may substitute for each other in the sense that the extent to which the consumers' desire is satisfied in one period may have an influence on the price he will be willing to pay in a subsequent period. It must, however, also be clear that if satisfactory results can be obtained without this variable an important possible source of ambiguity may be avoided, and the basis for prediction may also be improved.
5. The consumers' price index was introduced as a measurement of the prices of all goods. Such prices may have important effects on demand prices of a commodity. It has been illustrated[4] that such effects are twofold:

---

* Based upon a master's thesis submitted by J.J. Vosloo at the University of Pretoria.

1) Douglas, W.S. and Mullins, A.J., Analysis of the 1961 Orchard Survey, The Deciduous Fruit Grower, Vol.13, 1963, pp. 101-105.

2) Vosloo, J.J., 'n Ondersoek na die Struktuur van die Appelbedryf, Unpublished M.Sc.(Agric.) Seminar, University of Pretoria, 1967.

3) Pasour, Ernets C. and Gustafson, R.L., Intra-seasonal Supply and Demand Functions for Apples, Michigan State University Research Bulletin 10, 1966.

4) Hicks, J.R., Value and Capital, Clarendon Press, Oxford, 1965.

a substitution effect and an income effect. If a product is inferior (i.e. one with a negative income elasticity of demand), the income effect may cause the sign of the coefficient for this variable to be negative. However, since apples are considered to be normal consumption goods, the sign of this coefficient was a priori assumed to be positive.

6. The year itself was included as a variable in this study, since population changes, secular changes in taste, and similar phenomena may very well lead to shifts in the classical demand curve. One must, however, guard that the contribution of time is not very large relative to other independent variables. If this is the case, it may indicate that one or more major factors had not been recognised and used.[5] The sign of this coefficient is assumed to be positive.

7. Per capita income was included as it was assumed that the income elasticity of demand for apples would be positive and relatively large.

THE MODEL AND CHOICE OF DATA

The research model consisted of four linear equations, each consisting of price as the only endogenous variable, with a selection of exogenous variables as defined in the previous section. These equations were fitted by multiple least squares regression from time series data, and a choice could be made among the different equations after solution. The equations solved were as follows:

$$Ptm = a + bQ + cB + dO + ePtm\text{-}1 + fC + gCa + hM + iY \quad (1)$$
$$Ptm = a + bQ + cB + fC + gCa + hM + iY \quad \ldots\ldots \quad (2)$$
$$Ptm = a + bQ + cB + dO + fC + gCa + iY \quad \ldots\ldots \quad (3)$$
$$Ptm = a + bQ + hM + iY \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where Ptm = Price of apples in Rand per 100 pounds in month m of year t,

Q = Sales of apples in 100 pound units,

B = Sales of pears in 100 pound units,

O = Sales of oranges in 100 pound units,

Ptm-1 = Price of apples in Rand per 100 pounds, during the previous month,

C = Consumers' price index,

Ca = Index of per capita income,

M = Month,

Y = Year.

5) Foytik, J., Characteristics of Demand for California Plums, Hilgardia, Vol.20, 1951, pp.407-525.

Equation 1 contains all the assumed variables. Price during the previous month has been omitted from the other equations for reasons already stated. As there is a simple correlation coefficient of 0.348 between sales of oranges and month of the year, one might expect a certain degree of multicollinearity in an equation including both as independent variables. Thus, the effects of the two variables may not be separable from each other, since they happened to have moved together.[6] For this reason, month was included in equation 2, but omitted in equation 3, whilst the opposite was done with quantities of oranges. The two equations are similar in other respects.

In the fourth equation, only the quantity of apples, month and year were included. It was assumed that these should really prove to be the three most important causal variables in a demand equation explaining apple prices. Such an assumption would only be vindicated if the other variables were proven to be unimportant in the other equations.

Monthly data on apple prices and quantities of apples, pears and oranges sold on the nine major municipal markets were obtained from the Division of Agricultural Marketing Research. The data included the years from 1956 to 1965 inclusive, thus representing 120 observations.

The consumer price index was used as published monthly by the Bureau of Statistics. As the Bureau only publishes annual data on per capita incomes, monthly data were obtained by simply spreading annual differences evenly over the twelve months in a year. Time variables were included as consecutive numbers. Thus 1956 was allotted number one, 1957 became two, etc. The same procedure was followed with months of the year.

In their American study, Pasour and Gustafson[7] deflated apple prices by the wholesale price index in order to compensate for an increase in the general price level. Foote[8] justified such an adjustment on the grounds that if a doubling of all price and income variables had no effect on consumption, the effects of the general price level should be compensated for by deflation. He regarded such a premise to be reasonable with respect to most perishable items. Foytik[9], however, argued that unless such proportionality

6) cf. Valavainis, Stephen, Econometrics, McGraw-Hill, New York, 1959.

7) Op. cit.

8) Foote, R.J., Analytical Tools for Studying Demand and Price Structures, U.S. Department of Agriculture, Agricultural Handbook No.146, 1958.

9) Op. cit.

holds to a high degree, such adjustment could lead to erroneous results. In his view, the implication of proportionality was often not justified.

In view of Foytik's arguments, and also because the consumers' price index was included as a variable in the analysis, prices of apples were not deflated. In order to eliminate possible sources of multicollinearity between time variables, per capita income and consumers' price indices, the trend was eliminated from the latter two data series, and residuals derived from single regression equations with time were used for estimation purposes.

EMPIRICAL RESULTS

The statistical results obtained, together with the standard errors and tests of significance are shown in Table 1. The following tests of significance were used: The Student's t test for deviation of the calculated coefficients from zero and the F test for goodness of fit between data and each equation. The coefficients of determination (R^2) are also given in the table.

In Table 1, standard errors of coefficients are shown in parentheses below the regression coefficients, followed in the next line by the t values obtained. The degrees of freedom pertaining to calculated F values are given in parentheses below the F's concerned. One, two and three asterisks denote statistical significance at the 10%, 1% and .1% levels of probability respectively.

All equations yielded high coefficients of determination and high F values (significant at

TABLE 1 - Regression coefficients and statistical test results obtained with different demand equations for South African apples, 1956 -1965

Regression coefficients, standard errors and t values		Equation Number:			
		1	2	3	4
Intercept	a	2.6722	4.7851	5.5933	4.6099
Quantity apples	Q	-.00000784 (.00000338) -2.322*	-.00001584 (.00000285) -.5655***	-.00001984 (.00000313) -6.342***	-.0000173 (.00000267) -6.484***
Quantity pears	B	-.00000729 (.00000766) -.952	-.00000792 (.00000752) -1.053	-.00002283 (.00000119) -2.942**	
Quantity Oranges	O	.00000153 (.00000117) 1.310		.00000156 (.00000119) 1.302	
Price in previous period	Ptm-1	.4056 (.08816) 4.600***			
Consumers' price index	C	-.001237 (.001268) -.975	-.002151 (.001248) -1.724*	-.001511 (.001369) -1.104	
Per capita income	Ca	.00009805 (.0001463) .6701	.00004908 (.0001470) .3338	.00008695 (.0001615) .5381	
Month	M	.07214 (.02735) 2.637**	.1244 (.02461) 5.055***		.1337 (.02145) 6.234***
Year	Y	.01108 (.02621) .4230	.04765 (.02493) 1.911**	.0567 (.02798) 2.026**	.04304 (.0245) 1.756*
R^2		.6178	.5898	.5041	.5730
F		22.4386*** (8,111)	27.1401*** (6,113)	19.2229*** (6,113)	51.9489*** (3,116)

p = 0.001 in every case). Thus, the equations attained good fits of the data. With each of the equations it was possible to account for over 50 per cent of the variance of apple prices; in this respect, however, equation 3 fared somewhat worse than the other three. Equation 4, including only three independent variables, still explains over 57 per cent of the variance, and shows the best fit of data of all equations with an F value of over 50.

For purposes of prediction, equations 1 and 4 seem to be more appropriate than the other two; equation 1 may be used for very short-run purposes, when the price in the previous month is already known, while equation 4 should be preferred for more general and long-run purposes.

The Durbin-Watson test was used to test the equations for auto-correlation (sometimes called serial correlation in the residuals), which often occurs when time series data are used. The effects of auto-correlation are described as follows by Johnston:[10)]

1. The regression coefficients will be consistent and unbiased, but their standard errors will be biased,

2. the sampling variances of the coefficients will be an under-estimate of the true sampling variances, and

3. the predictions will be biased downward.

The d' values obtained for the four equations were 1.863, 1.510, 1.185 and 1.183, thus showing no significant auto-correlation in the case of equation 1, but increasing degrees of auto-correlation in equations 2, 3 and 4.

A transformation described by Johnston[11)] was used to overcome auto-correlation in equation 4. In this transformation, a coefficient, r, is obtained by the following equation:

$$r = \frac{\sum_{t=2}^{n} u_t \, u_{t-1}}{\sum_{t=1}^{n} u^2_{t-1}} \quad \text{where}$$

u refers to the residuals of the regression.

The transformed variables are then obtained by multiplying their values in the previous period by r, and subtracting the results from present values, thus:

$$P'_t = P_t - r\,P_{t-1}$$

Least squares regression was employed on the transformed variables of equation 4. The results are shown in Table 2.

The constant 2.3403 is an estimate of (1-r); thus, the relationship may be stated in terms of the original equation as:

$$Ptm = 4.6713 - .00001274Q + .1107M + 02822Y.$$

In applying the Durbin-Watson test to this equation a d' value of 2.148 was obtained, thus indicating the absence of auto-correlation.

INTERPRETATION

The roles of the different variables included in the analysis will now be discussed.

1. Quantity of apples

As could be expected from economic theory, this variable had a significant effect on apple prices with a negative sign. The price elasticity

TABLE 2 - Coefficients obtained with transformed variables, Equation: $Ptm = a' + b'Q' + h'M' + i'Y'$

	Constant term a	Quantity appels Q	Month M	Year Y
Regression coefficient	2.3403	-.00001274	.1107	.02822
Standard error	-	.000002932	.02227	.04224
t value	-	-4.348***	4.973***	.6680

Coefficient of determination R^2 = .352
Goodness of fit F (3,115) = 20.8250***

10) Johnston, J., Econometric Methods - International Student Edition, McGraw-Hill, New York, 1963.

11) Ibid.

of demand for apples could thus also be calculated. The elasticity, which changes as prices and quantities vary, may be defined as:

$$\in = \frac{dQ}{dP} \cdot \frac{P}{Q}$$

The elasticity is thus also the reciprocal of

$$\frac{dP}{dQ} \cdot \frac{Q}{P} ,$$

which can be calculated directly from the data presented above. Using equation 5 and average price and quantity data, the average price elasticity of demand was found to be -9.662, thus indicating an uncommonly high elasticity of demand for an agricultural product.

2. Month of the year

This variable played a significant effect in all the equations where it was included; thus, we have a strong indication that the demand curve shifts from month to month.

3. Year

The coefficient for this variable was significantly different from zero in equations 2, 3 and 4, but not in equations 1 and 5. Thus, there is some ambiguity in interpreting these results.

4. Competitive fruits

Quantities of oranges were not found to exert significant effects on apple prices. Thus, oranges do not seem to offer apples serious competition on the demand side. Quantities of pears, which were included in equations 1, 2 and 3, gave significant results only in equation 3 which, for reasons already advanced, cannot be regarded as the best explanatory equation. Thus it cannot be accepted that pears have an important influence on apple prices.

5. Consumer price index

This variable had a coefficient significantly different from zero in equation 2, but not so in equations 1 and 3. Its sign is negative, which is contrary to what economic theory leads us to expect. Being a normal commodity, one would expect apple prices to vary in sympathy with this variable.

6. Price in the previous period

This variable had an important and significant effect. This makes it a very handy variable to use in short run predictions, but not for more general use.

7. Per capita income

This variable does not seem to have any significant effect on apple prices.

CONCLUSION

In this study, various variables were tested as to their effect on apple prices. Four equations were used, one of which was transformed to overcome auto-correlation problems. Only two variables were found to be useful in general predictions of demand and price conditions as far as apple marketing in South Africa is concerned: quantity of apples and month of the year. The price elasticity of apples is very high - uncommonly so for an agricultural product.