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AN ECONOMIC ANALYSIS OF DEMAND AND SUPPLY FUNCTIONS FOR WHEAT (BREAD) IN SOUTH AFRICA, 1948 - 1981

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1. Introduction

This paper empirically estimates the supply function for wheat in South Africa from time series data. This function predicts to what extent acreages under wheat will decline (increase) as a result of relative decreases (increases) in the price of wheat. Secondly, the demand for bread is estimated using time series and cross-sectional data. Because the bread price is subsidised it is important to research the effects of such a subsidy on bread consumption. This information can also assist in determining consumers' and producers' proportional shares of the bread subsidy.

2. Supply function for wheat

2.1. National supply function

Few estimates of econometric farm supply functions have appeared in literature, in contrast to the numerous studies on demand. Noteworthy is the study on supply by Mark Nerlove. This has probably become one of the most referenced studies in applied econometric research, and the model he employed has since been dubbed the "Nerlove Model", which has also been extensively applied in demand literature and macro economic studies.

The supply function for wheat in South Africa is estimated in a form of the Nerlove lag model in (1).

$$\log S_t = 1{,}11 + \underset{(t=2{,}2)}{0{,}24 \log R_t - 1} + \underset{(t=7{,}0)}{0{,}72 \log S_t - 1} \quad \ldots\ldots\ldots 1$$

$R^2 = 0{,}86$

Where S_t is acreage (1 000 ha) under wheat in period t, R_t returns per ha from wheat in period t deflated by the consumer price index (CPI).

The Durban-Watson statistic is not shown because this statistic is not applicable to lagged exogeneous variables (Nerlove and Wallis).

Equation 1 estimates that a 1% increase in wheat price relative to the CPI will increase wheat acreage by 0,24% after the first season. It further indicates that if the price increase is in real terms and is permanent in the long term the increase in acreage may be as much as 0,86%. The short run elasticity is estimated as 0,24 and the long run elasticity is estimated as 0,86. The reason why the short run is inelastic is that if the price of a product increases, in the short run farmers may be reluctant to switch to a new crop but if the higher price persists more farmers will switch while existing producers may expand production.

The model therefore shows that wheat producers are not unresponsive to price incentives; in fact the price incentive explained 86% of the variation in planted acreage over the period studied.

In textbook supply functions, price is usually related to production. In model 1, acreage is taken instead of production because acreage planted more correctly reflects farmers' intentions to plant whereas production depends on climatic conditions as well.

In supply model (1) acreage planted was related to returns per ha which again is used as a proxy of profits per ha. Returns per ha is used instead of price because yield per ha increased substantially during the period. Returns per ha is the product of wheat producer price and yield per ha.

In (2) the returns variable was weighted from yield per ha of the main producing areas, which is a better reflection of yield increases over time since national yield per ha data are biased downwards owing to production expansion in more marginal areas.

$$\log S_t = 0{,}31 + \underset{(t=2{,}1)}{0{,}24 \log R_t} + \underset{(t=10{,}0)}{0{,}82 \log S_t - 1} \quad \ldots\ldots\ldots 2$$

$R^2 = 0{,}83$

Equation 2 estimates a short run elasticity of 0,24, similar to that of (1), but a long run elasticity of 1,3 which is larger. For explanation of variables included in (2) refer to (1).

2.2 Regional supply estimates

Different supply functions are fitted for winter and summer rainfall areas because alternative crops in these areas differ.

Supply function (3) is estimated for the winter rainfall area and (4) is estimated for the summer rainfall area.

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$$\log S_t = 0{,}83 + 0{,}18 \log R_t - 1 + 0{,}76 \log S_t - 1 \quad (t=1{,}7) \quad (t=7{,}6) \quad \ldots\ldots 3$$

$R^2 = 0{,}81$

$$\log S_t = 1{,}6 + 0{,}40 \log R_t - 1 + 0{,}55 \log S_t - 1 \quad (t=3{,}7) \quad (t=4{,}5) \quad \ldots\ldots 4$$

$R^2 = 0{,}80$

The short and long run elasticities of wheat supply in the winter rainfall area are estimated respectively as 0,18 and 0,75; the same estimates for the summer rainfall area are 0,40 and 0,87. The supply for the summer fainfall area is estimated to be more elastic than that for the winter rainfall area, which appears realistic since more expansion occurred in the former area during recent decades.

Nerlove estimated long run elasticities of supply for U.S.A. wheat of 0,9 and 1,1, allowing for an adjustment period. If no adjustment period is allowed his supply estimate for wheat is 0,47. Estimates for South Africa are short run 0,2 and long run 0,9 and 1,3. If it is taken into account that Nerlove's estimate of 0,47 refers to an intermediate term, then the S.A. and U.S.A. estimates are of the same order of magnitude. South African wheat farmers appear sensitive to price stimuli and the supply function appears not inelastic.

3. Demand function for bread

It is important to know whether consumers would consume more (less) bread if the price were lowered (increased), especially since bread is subsidised in South Africa.

During the period 1947/48 to 1980/81 the per capita bread consumption increased from 20,9 kg to 47,00 kg while the price of bread divided by the consumer price index fell by 20,7%. In this study it was found that the increased bread consumption per capita during this period can be attributed partly to a fall in real price of bread and partly to an increase in income per capita. White bread consumption fell from 20,8 kg per capita to 13,6 kg during the same period whereas brown bread consumption increased from 0,1 kg to 33,4 kg. The increase in brown bread consumption was found to be largely attributable to a fall in brown bread prices relative to white bread prices of 30% over the same period (models not shown in the interests of space).

In alternative demand models bread consumption data and wheat consumption data were taken as dependent on the price of bread and real income.

Wheat consumption figures in thousands of metric tons for the period 1915 to 1981 were obtained from three sources - the *Official Year Book of the Union of South Africa, 50 Years of Union Statistics* and the *Abstract of Agricultural Statistics.* Other data sources were Wheat Board reports, *Yearbook of South African Statistics* and supplement to S.A. Reserve Bank *Quarterly Bulletin.*

Consumption data on bread sold were obtained from Wheat Board Annual Reports for the period 1948 - 1981.

The price of bread is controlled by the Government, which implies that the price of bread is predetermined in a demand specification and that single equation least squares are appropriate.

In the various models fitted a better R^2 was observed when bread consumption was regressed on bread prices than when wheat consumption was regressed on bread prices, and only the former models are reported.

Model 8 estimates bread consumption per capita (CB) as a function of its own price deflated by the price index of food (PF) and real income (I).

$$\log CB = 11{,}23 - 45{,}99\,Pb + 0{,}0629\,I \quad (t=3{,}5) \quad (t=10{,}0) \quad \ldots\ldots 8$$

$R^2 = 0{,}93$

$d = 1{,}19$

Bread price elasticity = −0,22

In an original equation the d value was low. Model 8 is thus based on transformed data where the serial correlation was lagged out by calculating (X - r Xt - 1) values, where r is a serial correlation coefficient.

Model 8 estimates a price elasticity for bread of -0,22, implying that if bread prices increase in real terms by 1% there will be an estimated fall in consumption of 0,22%. The R^2 and t values are highly significant in model 8, which inspires confidence in the relation.

In (9) bread prices are deflated by the consumer price index, while the other variables are the same as in (8).

$$\log Bb = 11{,}19 - 55{,}32\,Pb + 0{,}0651\,I \quad (t=3{,}4) \quad (t=9{,}8) \quad \ldots\ldots 9$$

$R^2 = 0{,}86$

$d = 1{,}33$

Bread price elasticity = −0,24

Model 9 is also based on transformed data from which serial correlation is lagged out.

The price elasticity of bread is of similar magnitude in both models. In alternative models, wheat consumption was taken instead of bread consumption. The R^2 then dropped to as low as 52% and the bread price elasticity was estimated at -0,19, which is remarkably close to that estimated in models 8 and 9. Different income elasticities were observed when bread and wheat consumption figures were used in demand models and it was decided to estimate income elasticities from cross-section data in the next section. Greater accuracy in the measurement of income elasticity can be attained from cross-section data than from time series data.

The price elasticity estimated for bread of -0,23 for South Africa is slightly less than the -0,32 reported by Ritson for Britain. Bread is, however, a necessity and this implies that the price elasticity is low. The estimate for South Africa appears realistic while the estimate for Britain appears high.

4. Income elasticity of demand for bread (Ey)

Income elasticities of demand for bread and bread-type products are estimated for the different population groups - Whites, Blacks, Coloureds and Indians - in selected areas for 1980 from cross-section data obtained from consumer surveys conducted by the Bureau of Market Research.

The following data sources were consulted: Loubser (1980), Loubser and Martins (1980), Nel (1975) and Van Wyk (1980).

Elasticity coefficients were derived for Indian, Coloured and Black multiple households; an income elasticity estimate of 0,25 for White households for grain and grain products was used as a proxy for White income elasticity of demand for bread since figures for bread consumption by income group were not available for Whites.

The derived income elastiticy coefficients are weighted (using total household expenditure on food by population group for 1975 as weights) to produce an overall income elasticity estimate for South Africa.

To estimate the income elasticity coefficients, consumption expenditure in rands is used as a proxy for bread consumption (Ct) and is taken as a function of income, the independent variable, Yt:

$$C_t = a + b_1 Y_t + e_t$$

In terms of this function, the derived elasticity coefficients are reported below:

(a) Indian multiple households (Durban, 1980):

$$C_t = 57{,}293 + 0{,}011 Y_t \quad \dots\dots\dots\dots (5)$$
$$(t = 3{,}71)$$
$$R^2 = 60{,}4\%$$
$$E_y = 0{,}4495 \text{ (Income elasticity)}$$

(b) Coloured multiple households (Cape Peninsula, 1980):

$$C_t = 77{,}606 + 0{,}010 Y_t \quad \dots\dots\dots\dots (6)$$
$$(t = 3{,}97)$$
$$R^2 = 63{,}6\%$$
$$E_y = 0{,}3613 \text{ (Income elasticity)}$$

(c) Black multiple households (Vaal Triangle, 1980):

$$C_t = 61{,}192 + 0{,}007 Y_t \quad \dots\dots\dots\dots (7)$$
$$(t = 2{,}45)$$
$$R^2 = 50\%$$
$$E_y = 0{,}3114 \text{ (Income elasticity)}$$

(d) White multiple households (South Africa, 1980):

Ey is taken as 0,25 - the figure recorded by Nel (1980) for the Ey for grain and grain products applicable to White households.

All coefficients had the expected positive sign and t values were significant. Only the R^2 value for Black multiple households in the Vaal Triangle indicated a poorly fitting function.

The weighted income elasticity of demand for bread and bread-type products in South Africa is thus estimated by:

$$\frac{1968\ (0{,}2500) + 1875\ (0{,}3114) + 437\ (0{,}3613) + 209\ (0{,}4994)}{4489}$$

Total household expenditure on food is used as weights and is taken as a proxy for expenditure on bread.

In terms of this income elasticity of demand coefficient (or more accurately an income elasticity of expenditure coefficient), a 1% increase in income would result in a 0,3% increase in expenditure on bread and bread-type products, or an increase in quantity of wheat consumed in terms of 1980/81 consumption figures of 5 100 metric tons.

Given an equal precentage increase in income, Indian households would appear relatively more inclined to increase expenditure on bread than other population groups.

The income elasticity of 0,3 for bread for South Africa can be compared with similar estimates for the following countries: U.S.A. (-0,3), U.K. (-0,2), Brazil (0,4), Kenya (0,8), India (0,5) and Indonesia (1,0) (Ritson). Rockwell, cited by Moriak and Logan, estimated that the income elasticity changes from 0,20 for low income consumers to -0,08 for high income levels. The South African estimate appears realistic; because of the large Black population one would expect to find that bread is not an inferior commodity as in the U.S.A. and the U.K. but a normal commodity as in the less developed countries.

According to the Slutsky-Schultz relation (Wold and Jurèen) the income and price elasticity for a particular commodity should sum to zero if cross price elasticities are zero. In the case of bread one can assume that cross price elasticities are small. Income and price elasticities for bread estimated for S.A. respectively as +0,3 and -0,2 are numerically of the same order of magnitude and sum approximately to zero, which conforms to the Slutsky-Schultz relation. This relation casts some doubt on the price elasticity of -0,3 and income elasticity of -0,2 reported for Britain by Ritson (p. 26, 34).

The Hicks-Allen and Slutsky-Schultz relations (Wold and Jurèen) further indicate that price elasticities of necessities generally exceed their income elasticities. This implies that the price elasticity estimated for bread for South Africa may be as high as -0,3.

5. Welfare effects of subsidy

The consumer share of the bread subsidy is:

$$Es / (Es + Ed) \quad \dots\dots\dots\dots 8$$

Where Es = elasticity of supply and Ed = elasticity of demand.

According to section 3, Ed estimated as -0,2 and the average of the long and short run supply is

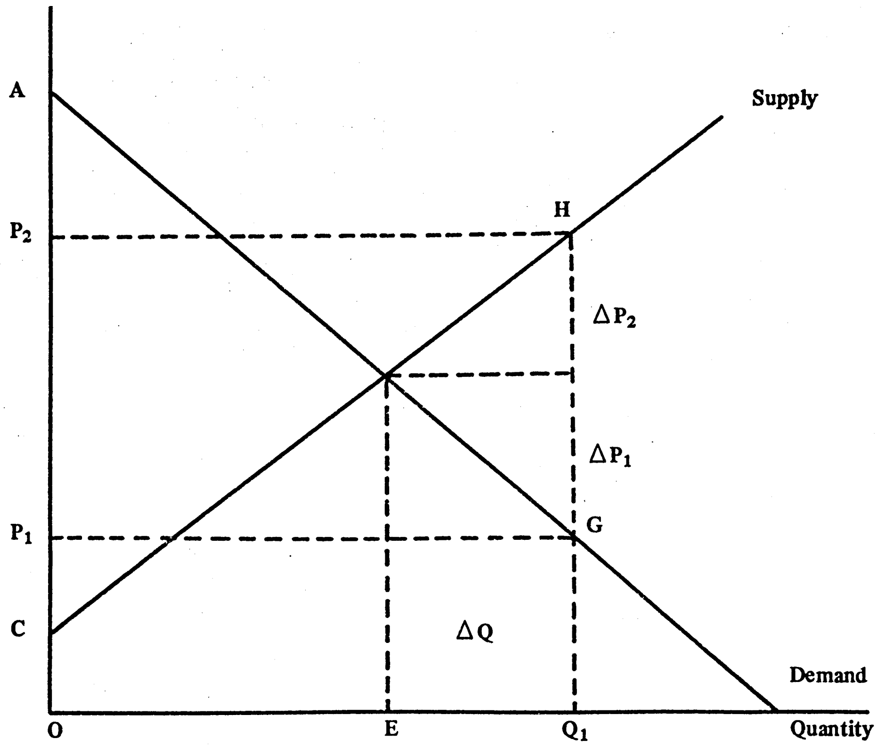

FIG. 1 - The effect of a bread subsidy on supply and demand

estimated as 0,5 (section 2). The consumer share of the bread subsidy is thus $+0{,}5 \ / \ (0{,}5 + 0{,}2) =$ 71% and the producer share is 29%. Although it would be wise to treat any economic (or econometric) prediction with caution it appears reasonably that consumers would gain more from the bread subsidy than producers. Because wheat can be imported for most years at lower cost than the S.A. producer price one would expect that producers in reality gain more and consumers less from the subsidy than the above estimates show.

The following equation determines the extent to which the bread subsidy stimulates bread consumption (Figure 1).

$$\Delta Q = \frac{Q_1 \,.Es \,.Ed \,.P_2 \,.S}{P_2 \, Es + P_1 \, Ed} \quad .... \quad 9$$

where ΔQ = increase in consumption
Q_1 = current consumption with subsidy
P_2 = producer price
P_1 = consumer price
S = subsidy rate $(P_2 - P_1)/P_2$
Es = elasticity of supply
Ed = elasticity of demand

The 1980/81 figure for the corresponding variables are $Q_1 =$ R385 million, $P_2 = 1{,}42$, $S = 0{,}30$, $P_1 = 1{,}0$, $Ed = -0{,}20$ en $Es = 0{,}5$,

According to the above calculation if the 1980/81 subsidy on bread of R162 100 000 is terminated then consumption of bread would fall by 5,2% or by 88 000 tons of wheat.

The free market price in the absence of imports can be determined as:

$$P_1 + \Delta P_1 = 1 + \frac{\Delta Q}{Ed} \cdot \frac{P_1}{Q_1} \quad .... \quad (10)$$

The variables are defined above. According to this model if the current subsidy of R162 100 000 is terminated (which represents a 30% subsidy) then it is estimated that the retail price will increase by 27%.

6. Conclusions

In the study the supply elasticity of wheat is estimated at +0,24 in the short run and about +0,9 in the long run. The price elasticity of demand for bread is estimated at -0,2 and the income elasticity is estimated at +0,3. During the period 1947/48 to 1980/81 the per capita consumption of bread increased from 20,9 kg to 47,0 kg, which is a significant increase.

In models estimated it was shown that the increased bread consumption can largely be attributed to a fall in the real price of bread of 20,7% and an increase in real income per capita of 50%.

Using these estimates it was calculated that if the present subsidy of R162 million on bread were terminated the consumption of bread would fall by 5,2% or 88 000 tons. The "free market" retail price of bread is estimated to be 27% above the current retail price.

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