Price leadership in the South African carbohydrate market

Helmke Sartorius von Bach
Faculty of Agriculture, University of Pretoria
Johan van Zyl
Faculty of Agriculture, University of Pretoria

Abstract

Price leadership in the South African carbohydrate market was analysed by removing the deterministic nature of time-series, filtering and causality determination. To determine whether the national analysis is relevant to the whole of the South African carbohydrate market, results were compared to regional results. The national carbohydrate market shows strong mutual dependence, with white bread the price leader. The high mutual dependence and cross-price effects show that price intervention reduce market performance. Notwithstanding differences in regional consumption characteristics, separate analyses to determine price leadership seem to be unnecessary in the South African staple food market.

1. Introduction

Literature shows that non-competitive behaviour in food industries support the need to derive formal relationships between the food market structure, food industry conduct and food market performance (Holloway, 1991). The markets wherein economics take place are heterogenous with substantial product differentiation, which results in a structure of non-competitive behaviour such as entry deterrence through product proliferation or excessive levels of promotion (Schmalensee, 1978; Connor, 1981; and Zellner, 1989). This duality between homogenous-product and heterogenous-product equilibrium leads to the reduction of market performance. The aim of this paper is to determine price leadership in the South African carbohydrate food marketing system, which also is an indication of the degree of effective functioning of the South African carbohydrate market.

2. Price policy for carbohydrates

Pricing is a continuous process of adjusting to the last potential buyer's fluctuating utility with respect to consumption of the product, and is directed at persuading this interested buyer to purchase. The principle of marginal utility and the consumer surplus concept are only met at the ultimate price in a well-formulated price policy environment.

Numerous studies have shown that price discrimination against agricultural producers leads to stagnation (Bale & Lutz, 1979; Mergos, 1987; and Lubbe, 1992). Hence, numerous suggestions for the removal of, or at least reducing, the price discriminatory factors. Taylor & Phillips (1991) found that internationally, price protection of carbohydrate commodities was the highest to maize producers and the weakest to rice.

Food prices have important implications to food security and trade. A marketing system contributes to food security by creating incentives of transportation, storage, processing and influencing the prices. However, no amount of improved market efficiency can compensate for structural food deficits. Marketing actions for food security should be based on access for private incentives actively improving both the availability and affordability of food marketed in food deficit areas. If trade reform improves and resource allocation become more efficient, price support programmes may be inappropriate.

For the purpose of market planning and structural adjustment, knowledge concerning price leadership and time lags can be regarded as a prerequisite to analyse food policy. Price interrelationships may involve a degree of causality, particularly when one product plays a residual role in a market dominated by another product (Groenewald, 1987). The extent to which some prices affect one another, was identified and used in evaluating policy by Grant, Ngenge, Brorson & Chavas (1983) and Van Zyl, Van Heerden, Groenewald & Vivier (1992). The latter showed that results are useful for purposes of reviewing some aspects of market control in the South African meat market. Grant *et al.* (1983) identified relationships among prices of related grains and found that in the US grain prices influence each other and that rice prices show very little reaction to changes in the prices of grains.

3. Methodology

To determine relationships among prices of related carbohydrates in South Africa and to provide some evidence on how the market reacts and adjusts to new information, a similar analysis based on time-series data was conducted. The first step in the analysis is to remove the deterministic nature of the time-series, which, by means of differencing, will transform the time-series into stationary-stochastic processes, where the mean and covariance are no longer a function of time (Gregory, 1975). The second step consists of filtering the stationary-stochastic components by means of simple autoregressive models of the order p, so that the residuals are reduced to white noise (Grant *et al.*, 1983). This means that no further correlations between the series exist (Box & Jenkins, 1976). Step three consists of the determination of causality between series by means of the Haugh-Pierce causality tests. In step four, the dynamic interaction of the various commodity prices (carbohydrates) is investigated by applying multivariate AR(p) models to the filtered price series.

The data consist of various carbohydrate prices, which are weighted monthly national retail trade prices of maize meal, rice, white bread, brown bread and potatoes in the RSA for the period January 1984 to December 1990. The brown bread price was used as a control for white bread. To analyse these time-series, the approach followed was based on those followed by Grant *et al.* (1983) and Van Heerden (1987). Their approach, and the use of causality tests are not without problems. Economic realism and logic must be applied when interpreting the results. Despite potential pitfalls, price leadership is a functional method for quantifying price relationships between commodities (Sims, 1977; Pierce, 1977a & b; Bishop, 1979). First chi-square tests are used to identify the existence of relationships among grain prices. The estimation of autoregressive (AR) time-series models then provides a basis for analysing dynamic price behaviour. The calculation of dynamic multipliers from the autoregressive models gives estimates of net impacts that are useful in economic analysis (Grant *et al.*, 1983).

The statistical theory of time-series analysis assumes that the series to be investigated is stationary; that is, the mean and covariance are not functions of time (Chow, 1975). The first step in the analysis was to filter out the deterministic trend (trends, seasonal, cyclical and irregular components) of the series, leaving only stationary stochastic components. This was done by making use of the PROC X11 (SAS, 1988) procedure. The X11 procedure is used to adjust for seasonal variation in time-series by means of additive or multiplicative adjustment, based on the assumption that the fluctuations can be measured in the original series and can be separated from trend, cyclical and irregular fluctuations.

The extent to which carbohydrate prices affect each other can be partially evaluated by empirical tests of causality. Each price series was filtered with univariate autoregressive models to reduce the residuals to white noise. Given the choice of the AR order (p), the univariate AR models and resulting residuals were estimated. To test the adequacy of the AR filters for reducing the series to white noise, the Box & Pierce Q statistic to the residuals was applied (Box & Pierce, 1970). If the AR filters were adequate, that is, if the calculated Q statistic is less than the chi-square value, no autocorrelation should exist in the residuals of each series.

The empirical use of these tests is not without problems. If relevant variables have been omitted, as happens in the analysis of many economic time-series, one is more likely to identify a feedback structure than a unidirectional system of causation (Bishop, 1979; Van Zyl *et al.*, 1992). The results of the causality analysis should be interpreted with caution. However, causality analysis does provide some useful information concerning the interrelationships among economic time-series and can be directly related to the efficiency of each market (Grant *et al.*, 1983).

In the case of closely related markets, it is useful to extend this approach by considering several price series simultaneously. When two series are analysed jointly, the causality tests can provide some evidence on how each market reacts to information reflected by its own as well as other prices. It may be that, while a particular market adjusts rapidly to changes in its own price series, changes in other markets are not so easily assimilated. Causality tests help to reveal how a market processes both kinds of information (own efficiency and cross efficiency) (Grant *et al.*, 1983). One limitation in the causality tests is that it is not clear how causation at different lags is to be derived or interpreted (Van Zyl *et al.*, 1992). When the chi-square tests of the cross correlation of univariate innovations indicate that two variables are not independent, the nature of the dependence structures needs to be specified. This can be accomplished by further joint analysis of the bivariate short-term series.

When market efficiency is investigated by means of univariate analysis of price series, the carbohydrate market is studied as if it functions in isolation (Grant *et al.*, 1983), which is unlikely in the case for any of the South African carbohydrate products. It is more likely that the markets for various commodities or for the same commodity at different locations have some influence on one another. This means that the single market approach may become inefficient when the relevant information set is expanded to include other price series. Bivariate analysis is a first step towards generalising the univariate, weak form test of market efficiency, as well as for evaluating directly the causal relationships among the commodity prices.

When a market is found to be inefficient, it is worthwhile to study the dynamic properties of the model for that market so as to understand how long it takes for the impact of changes to be transmitted throughout the market. The dynamic properties of the models were investigated by means of dynamic multipliers, which measure the reduced form impact of the lagged values of the variables on current values (Chow, 1975). Such multipliers have the advantage of summarising in a simple way complex interactions that may exist among related price series. In an attempt to measure the speed of adjustment, the number of time periods needed for the intermediate-run multipliers to stabilise within 5 per cent of the long-run multipliers was calculated. Such information helped to provide an economic interpretation of the results (Grant *et al.*, 1983; Dhrymes, 1973).

4. Results

4.1 National results

After the time-series was transformed into stationary-stochastic components by means of differencing, the price series residuals of the univariate AR models were tested for white noise by means of the Q statistic (Box & Pierce, 1970). If the AR(p) filter is sufficient, the calculated Q statistic will assume a value of less than the chi-squared value. For this national carbohydrate analysis, a first difference filter was sufficient only for bread and for maize meal. For rice and potatoes a second difference filter was needed to generate stationary series. The Q statistic for potatoes of 30.089 is more than the Chi-square $value_{13,0.05}$ of 22.4. Furthermore, the autocorrelation check of residuals showed a probability value of 0.032 (significance level of 0.05) for the 12 lags, indicating that no significant further calculations (multipliers and the period of adjustment) can be determined. The reasons why no white noise was obtained for potato prices are twofold, namely that South Africans regard potatoes as both a carbohydrate and as a vegetable. Thus, potatoes have characteristics which differ from the other carbohydrates. Furthermore, the production of potatoes has an extreme effect on prices, i.e. in times of surplusses, huge quantities of potatoes are dumped, while there are shortages a few months later on the national markets (Langley, 1990; Elliott, 1991). Elliott (1991) found that potatoes are most price sensitive and that price fluctuations are out of proportion relative to other carbohydrates. From these results Haugh-Pierce causality tests were conducted.

Table 1 shows that all types of carbohydrate prices influence one another at the one per cent level of significance (the null hypothesis on independence is rejected). The weakest price relationship exists between rice and potatoes. White bread prices had an instantaneous causality on brown bread and on potato prices, while brown bread prices had this effect on maize meal, all at the one per cent level of significance. At the one per cent level of significance, rice showed no effect on brown bread. At the 10% level of significance, instantaneous causalities (reaction within a month) existed between rice and potatoes. All other series show indications of lags. Rice exhibited no significant causality on white bread, while maize meal had no effect on potatoes at the 10% significance level.

Given the Haugh-Pierce causality results, the calculated long-run multipliers (both Series 1 on 2 and Series 2 on 1) and their standard errors from the bivariate AR estimates (shown in parentheses), are given in Table 2. These values provide a basis for measuring own-price and cross-price effects and the extent to which South African carbohydrate prices tend to move together (instantaneous or with lags). The intermediate lag multipliers are calculated at a 5% significance level at the given period of adjustment for various series.

4.1.1 White bread

The highest causality result was selected to determine which price series leads. According to the above, white bread prices lead maize meal, rice and potato prices. These tests also indicate a joint dependency between white bread and all other carbonydrate prices. The relationship between white bread and potatoes is instantaneous (within one month). However, this result can be misleading due to the fact that no white noise could be obtained for potatoes and should be used with care.

From the bivariate models, the long-run multiplier effect of white bread on brown bread is significantly different from zero. This is to be expected as prices were controlled during the period under consideration, and price increases for both white and brown bread were announced simultaneously. Instantaneous causalities are not shown in tables but are described where necessary. The impact of white bread prices on maize meal prices is less (0.481) than on brown bread prices. The effect of a price change on white bread and rice (0.133) is small and takes 15 months to manifest itself. The long-run multiplier effect of white bread on potatoes is negligible (0.045). The biggest immediate effect occurs between white bread and brown bread and maize meal.

4.1.2 Brown bread

The chi-square tests of independence indicate a strong relationship between brown bread and all other carbohydrates. Similar to white bread prices, brown bread prices lead maize meal, rice and potato prices. White bread prices lead brown bread prices. According to the long-term effects (Table 2), it is clear that the effects of changes in brown bread prices on maize meal (0.277) and rice (0.116) are smaller than the price effect on white bread. The adjustment period of these changes is longer, as is the case with white bread prices. Brown bread and white bread are closely related - which is a logical result, since price changes were announced on the same day.

4.1.3 Maize meal

Table 1 shows that maize meal prices lead the prices of rice. Bread and potato prices lead the price of maize meal. The high dependence between maize meal and white bread, rice and potatoes, respectively, as indicated by the large cross-correlation coefficients (Table 1), supports the importance of maize meal in the South African carbohydrate market. No instantaneous causality is experienced by maize meal on white bread. The long-run effect takes one month to filter through.

4.1.4 Rice

White bread, brown bread, maize meal and potato prices lead rice prices. Instantaneous causality exists only between rice and maize meal with effects of 0.563 cents, respectively. The use of potatoes as a carbohydrate (no white noise) may be misleading. Excluding potatoes from the analysis, the price effects, where rice prices are concerned, are relatively small.

4.1.5 Potatoes

Due to the fact that the potato price series could not be changed to white noise, the results obtained, in the case of potatoes, should be interpreted with care. Potato prices are supply driven (Langley, 1990; Elliott, 1991). However, potato prices are influenced by other carbohydrates, and, according to the analysis, they lead the prices of maize meal.

4.2 Regional results

Regions analysed were three coastal areas (A, B and C), the metropolitan area and lastly the rural areas of South Africa. According to the instantaneous causalities and the reaction periods, it seems that coastal area C and the metropolitan area have the most efficient carbohydrate markets in South Africa. The metropolitan area showed results similar to the national market, while some similarities exist between the adjacent coastal areas A and B. In maize producing areas, maize meal prices generally exhibit no significant causality on bread prices. Except for the results obtained in the rural and national analysis, no significant causality between potatoes and brown bread exists in any region. Potatoes had no effect on rice or on white bread in the non-potato producing areas. In respect of regional price leadership, white bread prices were the leaders in all areas.

In the metropolitan area, where the population in general spend less on food than in the rural and coastal regions, white bread was the carbohydrate price leader, followed by rice, while maize meal and rice were generally led by wheat products. Coastal area C had no strong price leader. This is partly supported by the high dependence between all carbohydrates, the relativly different population composition and consumption pattern and the fact that consumers are consistent in their consumption habits in this area (Sartorius von Bach, 1992). It can, however, be concluded that white bread is the price leader, while maize meal plays a minor role in the carbohydrate market. Because no white noise was obtained for rice, it is difficult to determine other price classifications. The only area where all price series were white noise was the non-producing carbohydrate area, coastal area B. Both white and brown bread were price leaders in this area, followed by maize meal. Rice and potato prices were only influenced by other carbohydrates and thus played a minor role in coastal area B. In the carbohydrate market in coastal area A, both white and brown bread were carbohydrate price leaders. The other carbohydrate prices played a minor role in this area. As shown by the rural analysis, white bread is the carbohydrate price leader in the rural areas of South Africa, followed by rice.

5. Conclusions

Price leadership and time lags may be regarded as prerequisites for purposes of market planning, forecasting and knowledge concerning analysis of the carbohydrate market. It was found that the national carbohydrate market showed a strong measure of mutual dependence. Rice prices have no effect on white bread or brown bread, nor on potato prices. Because of no white noise for potatoes (mainly because they are supply driven) and the difference in characteristics compared with carbohydrates, potatoes are regarded nationally more as a vegetable. The potato results therefore may be misleading and should be interpreted with care. Instantaneous causality was obtained between prices of white bread and brown bread, between maize meal and rice and potatoes, and between rice and potatoes. This instantaneous causality is an indication of quick adjustment (one month or less than one month) and is also indicative of market efficiency. The most important effects of immediate changes in prices occur between white bread and brown bread, which is to be expected due to the operation of the pricing system.

The long-run multipliers from the bivariate AR models generally showed statistically significant coefficients, but most of these were small. The only significant price effects were those between white bread and brown bread, and between white bread and maize meal. From this it is difficult to determine a price leader or leaders for the analysed carbohydrates. However, it can be concluded that white bread is the most prominent carbohydrate price leader in the national South African carbohydrate market, followed by maize meal products, and that maize and rice are led by wheat products. These results are consistent with *ex ante* expectations as dictated by the various pricing policies followed in respect of each carbohydrate.

To determine whether the national based limitations of analysis are relevant to the South African carbohydrate market, the analyses were expanded and compared with regional results showing no big difference between the levels. The high mutual dependence shows that one carbohydrate commodity's price policy cannot be seen in isolation. Price intervension for one commodity affects the marketing performance of the South African carbohydrate industry. Provided adequate competition in private enterprise, a deregulating adjustment in the carbohydrate market is likely to benefit both producers and consumers. Adjusting policies should promote food security and support privatisation by reducing price protection in the carbohydrate industry.

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Table 1: Haugh-Pierce chi-square statistics for selected national carbohydrate prices

Carbohydrates		Null hypothesis			
Series 1	Series 2	Series 1 does not cause series 2	Series 2 does not cause series 1	No instantaneous causality	Independence
White bread	Brown bread	185.239	160.378	99.689	284.928
White bread	Maize meal	301.699	44.145	29.580	331.279
White bread	Rice	160.041	10.567	10.550	170.591
White bread	Potatoes	127.378	87.240	75.611	202.989
Brown bread	Maize meal	148.833	67.664	57.200	206.033
Brown bread	Rice	131.119	24.972	23.424	154.544
Brown bread	Potatoes	69.015	44.987	39.296	108.311
Maize meal	Rice	325.503	57.690	55.871	381.374
Maize meal	Potatoes	143.360	234.593	231.201	374.561
Rice	Potatoes	26.228	51.608	46.351	72.579
Rejection of the null hypothesis at	10% level	22.300	22.300	41.400	22.300
	5% level	24.996	24.996	45.000	24.996
	1% level	30.578	30.578	52.000	30.578

Table 2: Long-run multipliers from bivariate AR models of national carbohydrates

Carbohydrates		Multipliers		Adjustment period (months)	
Series 1	Series 2	Series 1 on 2	Series 2 on 1	Series 1 on 2	Series 2 on 1
White bread	Brown bread	0.762 (0.142)	0.455 (0.157)	1	1
White bread	Maize meal	0.481 (0.066)	0.646 (0.194)	5	1
White bread	Rice	0.133 (0.021)	0.859 (0.707)	15	1
White bread	Potatoes	0.045 (0.024)	3.614 (0.806)	4	6
Brown bread	Maize meal	0.277 (0.982)	0.846 (0.230)	10	6
Brown bread	Rice	0.116 (0.021)	2.279 (0.718)	15	2
Brown bread	Potatoes	0.023 (0.023)	2.278 (0.850)	4	4
Maize meal	Rice	0.213 (0.028)	0.322 (0.453)	11	1
Maize meal	Potatoes	- -	2.644 (0.384)	-	12
Rice	Potatoes	- -	- -	-	>15