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RESEARCH NOTE: HUMAN CARBOHYDRATE DEMAND IN SOUTH AFRICA

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This note discusses aspects of carbohydrate consumption, prices of carbohydrates and interdependence in the carbohydrate market. Knowledge gained is used to analyse the effects of relative prices and income on the consumption of different carbohydrates in South Africa. Price and income elasticities of demand estimated by the traditional single equation approach and a systems method do not differ markedly. However, because of the interdependence between carbohydrate consumption, the systems method seems to be more appropriate than the traditional single equation approach. Relative prices of carbohydrates and income per capita play a major role in influencing the consumption of different carbohydrates.

Die menslike vraag na koolhidrate in Suid-Afrika

Hierdie referaat bespreek aspekte van styselverbruik, pryse van stysels en interafhanklikheid in die koolhidraatmark. Kennis ingewin is gebruik om die effek van pryse op die verbruik van koolhidrate in Suid-Afrika te ontleed. Elastisiteite verkry met behulp van die tradisionele enkelvergelyking benadering en 'n sisteembenadering verskil nie betekenisvol nie. Die gebruik van 'n sisteembenadering eerder as 'n enkelvergelyking benadering is egter meer korrek vanweë die interafhanklikheid tussen koolhidrate. Relatiewe pryse en *per capita* inkomste speel 'n deurslaggewende rol in die bepaling van die verbruik van koolhidrate.

1. Introduction

The carbohydrate market in South Africa consists mainly of the maize, wheat, potato and the rice markets. The flow of carbohydrates through marketing channels from producer to the consumer changes over time. Increased supplies and a varying demand have been largely responsible for altering the marketing system and the need to analyse human carbohydrate consumption. Pricing issues in the various segments of the carbohydrate market in South African have been researched and reported on by Cadiz (1984), Cownie (1991), Elliott (1991), Elliott & Van Zyl (1991), Langley (1990), Niebuhr (1991), Nieuwoudt (1990) and Van Zyl (1986).

This note briefly discusses aspects of carbohydrate consumption, prices of carbohydrates and interdependence in the carbohydrate market, mainly by referring to results of earlier research. It then analyses the effects of relative prices and income on the consumption of the different carbohydrates in South Africa using the traditional single equation method and a systems method.

2. Carbohydrate consumption

World consumption of food has changed since the 1960's in that the consumption of carbohydrates has decreased, while the consumption of proteins, fats and other products has increased. This tendency is due to the replacement of carbohydrates by proteins and fats. The transfer of the affluent society's perceptions of carbohydrates to the poor contributed to a change in the pattern of direct carbohydrate consumption to an indirect consumption (carbohydrates fed to white/red meat animals instead of people themselves consuming carbohydrates). Despite the importance of food as energy, foods rich in carbohydrates are regarded as inferior (Readers' Digest, 1985), yet they are enjoyable to eat and are the most economical in regard to nutrients produced, stored or bought.

2.1 Maize and maize products

Traditionally there are three domestic markets for maize - the human, animal and the industrial markets. The industrial market refers to that market where maize (white or yellow) is refined to yield products such as starch and glucose. White maize is primarily used for human consumption, and yellow maize is mainly consumed by animals. Although the latter market was relatively small, it has shown a steady growth in the past (Van Zyl, 1986) and is presently more important than human consumption.

Elliott (1991) summarises maize consumption patterns in Southern Africa as follows:

- ▶ The black population group is the major consumer of maize, accounting for 94 per cent of all maize meal produced in RSA, and 90 per cent of all maize products.
- ▶ Rural black consumption of maize is approximately one and a half times that of its urban counterpart on a per capita basis.
- ▶ In the total maize market, rural sales constitute approximately 70 per cent of all maize product sales. The urban market is gaining importance relative to the rural market.
- ▶ Market share varies over time and will depend on the unit used for its calculation as well as the data source. Analyses indicate that bread has become the most important carbohydrate source in urban regions, while maize is dominant in rural regions.
- ▶ The total per capita consumption of carbohydrates has remained relatively static for some time, with a marginal standard deviation. This tends to suggest that in per capita terms, the market for carbohydrates is limited.

- ▶ The maize meal consumer tends to be older and there is a traditional element associated with its use. Maize meal tends to be consumed by less affluent groups.
- ▶ Family size appears to be a major determinant of per capita maize consumption in metropolitan regions.

These findings imply that in the short term, positive movements in market share for one product will imply a shift away from another product. In terms of the total carbohydrate market, this makes the value of generic advertising on carbohydrates questionable (Elliott, 1991).

Sartorius von Bach (1992) indicated that aggregate consumption tendencies can be separated. A cyclical pattern of high amplitude followed by low amplitude existed from January 1984 to April 1987 with the cycles getting shorter. High consumption occurred in March 1984, April 1985, April 1986 and October 1986, while lower consumption was the rule in the months in between. During the above period, a trend of increased consumption of maize meal can be detected. In the period since May 1987, the general trend changed to a constant/decreasing consumption of maize meal. The monthly consumption had fewer high points and low points, and the amplitudes were less stable without clear cycles. An important reason for the decreased consumption of white maize is consumer resistance to white maize if yellow maize is added because of seasonal deficits.

On 1 May 1987 a structural change in the marketing system occurred in the maize industry. At that date, the Maize Board was allowed greater autonomy in the setting of prices and the establishment of a more market related policy. Since then, a significant turn around in monthly consumption of maize meal has become apparent. This trend, as indicated by the monthly data, was observed by Elliott (1991), using annual data. The structural change was from a fluctuating increased consumption to a more stable but constant/decreasing consumption.

2.2 Bread

In South Africa, wheat is grown mainly for human consumption in the form of flour and bread. Small quantities of a poorer quality are marketed as animal feed. About 55 per cent of the total quantity of flour manufactured from wheat is used in the production of bread; 33 per cent of the cost to manufacture a loaf of bread is represented by the cost of flour (Wheat Board, 1991).

According to Niebuhr (1991), the biggest consumption of wheat during the period 1984 - 1990 was in the PWV area, followed by Durban, Eastern Orange Free State (OFS) and the Cape Peninsula. Other regions showed contributions of less than 10 per cent of wheat consumed. Of all the types of bread, brown bread was mostly consumed, followed by white and whole wheat bread (Niebuhr, 1991). A statistically significant decrease in monthly consumption of brown bread of 0.61 per cent for South Africa was calculated, while white bread consumption increased by 1.22 per cent per month (Niebuhr, 1991). According to the Wheat Board (1991), a slight decrease in the consumption of standard bread was experienced during the last season while the consumption of other baked and meal products increased by 30 per cent per annum.

Niebuhr (1991) found that the seasonal trend of whole wheat bread and brown bread differed from that of white bread. He showed that consumption of bread is low during the period March to May and July. In October, white bread consumption is the highest and in January, the consumption of brown and whole wheat bread is the highest. Elliott (1991) found that bread consumed by

blacks is by the younger group and that it is accepted by all income groups, ranging from the relatively poor to the relatively rich.

A cyclical consumption pattern for both white bread and brown bread exists; the amplitudes for brown bread being higher than those for white bread. In the period January 1984 to June 1987, both types of bread followed the same increasing consumption pattern. Since then, white and brown bread have followed different patterns. White bread consumption continued its cyclical increasing trend until May 1990, after which consumption decreased. Brown bread consumption has shown a decreasing trend since June 1987, while the cycles tend to get longer. Structural adjustment in the maize industry and declining brown bread consumption appear to correspond.

2.3 Potatoes

Based on the average market share over a 15 month period in 1990 - 1991, potatoes made up 28 per cent of carbohydrate consumption in selected urban markets (Elliott, 1991). In general they contribute about 23 % to the carbohydrate market in South Africa. Potatoes are a filling form of carbohydrate, and are accepted by all income groups. Currently, whites purchase about 78 per cent of the potato supply (Elliott, 1991). Potato consumers tend to be better educated and the greatest consumption is in the younger market.

The monthly potato consumption fluctuates widely. In the period January 1984 to September 1987, monthly aggregate consumption fluctuated regularly with some outliers (October 1984, February 1985 and October 1987). Since then, there has been a tendency towards increased aggregate consumption, and cyclical consumption patterns have been observed. It is not possible to say whether this is the result of structural adjustment in the maize industry. This has important implications for the generic advertising policy of the Potato Board, which will be addressed later.

2.4 Rice

Analysing the urban market share of carbohydrates based on bar code scanning data, Elliott (1991) found that rice had a market share of 15 per cent. Rice is more particularly consumed by younger people in both the black and white markets. Elliott (1991) also found that rice is more important to the black urban population than the rural population. The majority of rice consumers are more affluent than are the non-consumers. The possibility exists that the poorer rural consumer, with a smaller family, is striving for the prestige image associated with a more expensive form of carbohydrate (Elliott, 1991).

3. Carbohydrate prices

Relative prices play a central role in economic theory in guiding consumption. Consumers are influenced in their decisions by advertising, the display space given to foods in various types of shops, packaging, convenience, as well as by prices. Notwithstanding complications introduced by non-price factors, consumers do react and respond to changes in the price of bread relative to prices of maize meal (Tomek & Robinson, 1990). These concepts provide valuable insight into human behaviour and necessitate the analysis of price effects in the carbohydrate market.

Because of the nature of the fixed price of bread as determined by the Wheat Board prior to March 1991, white bread and brown bread prices showed similar

patterns. White bread was more expensive than brown bread. The constant upward shifts in prices is a clear indication of the policies followed with respect to price determination, since prices were determined according to producer costs and thus incorporated inflation. Niebuhr (1991) found that the real bread price has been falling since February 1989.

Up to 1987, the prices of maize meal were influenced by the Maize Board and have been determined according to production costs (incorporate inflation) with an added margin. This supports the findings of Elliott (1991) that real retail maize meal prices in supermarkets are relatively constant. The prices of the above-mentioned carbohydrates are highly correlated with each other and with the inflation or consumer price index too - a result of the pricing system in the period 1984 to 1990.

The prices of potatoes and rice were not correlated with inflation. Prices of these products were not controlled by the government. Potato prices are mainly (> 70 %) determined by market forces on the fresh produce markets of South Africa (Langley, 1990). Elliott (1991) established with his "textbook" example of potatoes that this carbohydrate product is most price sensitive on a national level. According to this is only true for the period since July 1988 onwards. Both Langley (1990) and Elliott (1991) found that potato prices are supply driven. Prices of rice increased by the consumer price index, but on a cyclical pattern, and since 1988 they have increased even more in nominal terms.

4. Interdependence in carbohydrate consumption patterns

The total per capita consumption of carbohydrates in South Africa has remained relatively static, but has tended to decrease (Elliott, 1991). In his study, he argued that three factors are of importance for carbohydrate consumers - a variety in the choice of food, relative prices and convenience in terms of readiness to eat, since the human stomach is the fundamental limitation. Carbohydrates are selected according to relative prices to keep the consumption expenditure low and to obtain sufficient calories. This results in particular levels of demand for specific commodities changing with time.

Demands for carbohydrate commodities are, in reality, directly and indirectly linked to each other. Their related prices are mutually dependent, which, to a certain extent, is indicated by shifts in consumption caused by policy adjustments for one commodity. Substitutional and complementary effects between the basic carbohydrates were determined by various South African researchers. The traditional concept of a separate single evaluation of commodity demand is therefore an inadequate basis for predicting actual behaviour in the carbohydrate market. Ignoring the simultaneous nature of the interrelation between elements of the carbohydrate industry will lead to failures in estimating structure, conduct and performance.

5. Effects of relative prices on consumption of carbohydrates

The theory of consumer demand is rooted in the physiological and psychological needs of individuals. Demand is a behavioral relationship that describes how much of a product will be purchased at different prices under a carefully defined set of conditions. From the derivation of the demand function, the estimated price elasticity of demand makes it possible to estimate changes in the quantity of the good demanded with respect to changes

in its price, with (in general) all other conditions remaining constant. This *ceteris paribus* assumption does away with all vague qualifications concerning interrelationships between commodities, which leads to a system of simultaneous equations approach.

The data and method used are described first, after which the findings of recent local studies which have estimated income and price elasticities of demand based on the traditional single equation approach are reported. Realistic own-price effects, income effects and cross relationships estimated in this study using the simultaneous equations approach are then reported for comparison.

5.1 Data and method used

To estimate factors affecting the demand for various carbohydrates in South Africa, monthly data (January 1984 to December 1990) were used, sufficient to obtain enough degrees of freedom in time series analysis. The aim of determining demand curves is to estimate price and income elasticities for various carbohydrates. These curves are based on numerous limiting assumptions and historical data. The data consist of monthly national retail prices of maize meal, brown bread, white bread, rice and potatoes in South Africa. These sets of data are regarded by the Central Statistical Services (1991) as representative. Retail prices were deflated by the food price index (Central Statistical Services, 1991). Other data were supplied by the Maize Board (1991), Wheat Board (1991) and the Potato Board (1991). Per capita figures were determined by using population estimates obtained from the Central Statistical Services (1991), who provided disposable income too, which led to the determined real income per capita index.

The starch content in carbohydrates is used as a proxy for consumption, which is relatively static on a per capita basis, as indicated by Elliott's (1991) findings. The importance of carbohydrates in the human diet and some results obtained by Booth, Mather & Fuller (1982) indicate that this is feasible. Booth *et al.*, (1982) found that the rated pleasantness of eating a particular commonly used food of substantial energy value is a valid index of the level of appetite and satiation in an individual at a given moment. Both the appetite and the suppression of appetite for particular foods are determined by the association of the ingested starch content of the particular food.

Because of an expected joint dependence between carbohydrates in consumption, a wider system of equations is required, with one equation for each jointly dependent or endogenous variable. The three-stage least squares (3SLS) commonly used systems method was selected to determine the observed high mutual dependence of carbohydrate prices (Sartorius von Bach & Van Zyl, 1994), the importance of cross-price and income effects and to take cross-equation correlations into account.

An *ad hoc* demand system derived from an expenditure minimising framework without imposing the coefficient restrictions following from the consumer duality theory was used. The following system of structural equations was estimated, in which quantities per capita of maize meal, bread and potatoes are explained in terms of their own real retail prices, real retail prices of substitutes and the per capita income index:

$$\begin{aligned} Q_{WB} &= f(P_{WB}, P_{BB}, P_{MM}, P_R, P_P, I); \\ Q_{BB} &= f(P_{WB}, P_{BB}, P_{MM}, P_R, P_P, I); \end{aligned}$$

$$\begin{aligned}
 Q_{MM} &= f(P_{WB}, P_{BB}, P_{MM}, P_R, P_P, I); \\
 Q_P &= f(P_{WB}, P_{BB}, P_{MM}, P_R, P_P, I); \\
 Q_{Ex} &= f(Q_{WB}, Q_{BB}, Q_{MM}, Q_P, P_{WB}, P_{BB}, P_{MM}, P_P, I); \\
 \text{and} \\
 Q_Q &= f(Q_{WB}, Q_{BB}, Q_{MM}, Q_P).
 \end{aligned}$$

where

- Q_{WB} = human white bread consumption per capita
- Q_{BB} = human brown bread consumption per capita
- Q_{MM} = human maize meal consumption per capita
- Q_P = human potato consumption per capita
- P_{WB} = average deflated retail price of white bread
- P_{BB} = average deflated retail price of brown bread
- P_{MM} = average deflated retail price of maize meal
- P_R = average deflated retail price of rice
- P_P = average deflated retail price of potatoes
- Q_{Ex} = per capita carbohydrate expenditure
- Q_Q = per capita starch endosperm intake
- and
- I = monthly real disposable income per capita index.

Endogenous variables Q_{Ex} and Q_Q were determined to take the purchasing decisions of carbohydrate consumers into account, assuming that they are either concerned to get enough food or to keep expenditure on carbohydrates as low as possible, given a certain level of consumption. Q_Q shows the total per capita endosperm consumption (a proxy of saturation), while Q_{Ex} indicates the per capita total carbohydrate expenditure. The model could be improved by including an urbanisation proxy variable to determine consumer preferences. However, because of aggregation problems of the national statistics, this proxy was not included.

5.2 Empirical results and discussion

Income and price elasticities of demand are estimated and compared with results reported elsewhere, which provide important policy information regarding pricing decisions. Past research (summarised in Table 1) ignores the simultaneous nature of the interrelations among elements of the carbohydrate market. Estimates obtained by the 3SLS model are compared with these single equation estimates.

Table 2 provides the estimates of coefficients and elasticities using multiple regression analysis (Proc Stepwise) and the final 3SLS model (3SLS) on monthly data for the period 1984 to 1990. The model equations were selected according to the criteria discussed above. The coefficients also indicate the elasticities, since the variables were expressed in logarithmic form.

5.2.1 Single equation approach

The Proc Stepwise showed that only the potato price and the income per capita index affected the maize meal demand for human consumption. The cross-price elasticity of demand of 0.111 shows that if the real price of potatoes increases by one per cent, the quantity of maize meal demanded will increase by 0.111 per cent *ceteris paribus*; if the income per capita increases by one per cent, the maize meal consumption will increase by 0.012 per cent *ceteris paribus*. From the above, potatoes are a substitute for maize meal. White bread consumption is affected by the white bread price (price elasticity of demand = -2.674), the brown bread price (cross-price elasticity of demand = 1.244), the rice price (cross-price elasticity of demand = 0.536) and the income index (income elasticity of demand = 0.007). A one per cent increase in the price of white bread results in a 2.674 per cent decrease on average in the consumption of white bread. Brown bread and rice act as substitutes for white bread. A one per cent increase in the national per capita

income will result in a 0.007 per cent increase in consumption of white bread *ceteris paribus*. The brown bread consumption is affected by the white bread price (cross-price elasticity of demand = 2.253), the brown bread price (price elasticity of demand = -2.783) and the income index (income elasticity = 0.007). Potato consumption was affected by the potato price (price elasticity of demand = -0.488) and the white bread price (cross-price elasticity of demand = -0.292). White bread acts as a complement to potatoes. This illustrates that potatoes are consumed as carbohydrates or as a vegetable.

5.2.2 Systems method

The weighted R^2 of the system of simultaneous equations of 0.7143 showed a good fit. Results of the 3SLS in Table 2 were obtained with both the purchase decision variables Q_{Ex} and Q_Q included. Considering maize meal consumption, the two variables included were the price of potatoes (elasticity coefficient = 0.192) and the per capita income index (elasticity coefficient = 0.006). The low income elasticity of demand illustrates that maize meal is regarded as a staple food. The price of maize meal has no statistically significant effect on the consumption of maize meal, even when the variable was forced into the model. The estimated coefficients of the variables affecting white bread, brown bread and potato consumption did not differ markedly from the first approach.

Comparing the above results with the determined single equation findings, it can be concluded that in general, the income elasticities are lower and the price elasticities are higher (except for RSA white bread and potatoes) than those reported in Table 1. The price of maize meal has no significant effect on consumption of any of the analysed carbohydrates, while the consumption of all carbohydrates other than maize meal were influenced by their own prices. The low income elasticities shown in Table 2 illustrate that the carbohydrates analysed are, in general, consumed as staple food.

Because of the interdependence between consumption of different carbohydrates, the systems method seems to be the most appropriate. The relative prices of carbohydrates and the income per capita variable do play a role in influencing which type of carbohydrate is fulfilling the required level of staple food satiation.

6. Conclusions

The carbohydrate market in South Africa consists mainly of the maize, wheat, potato and the rice markets. Bread contributes 25 per cent, potatoes 23 per cent, rice 5 per cent and maize products about 46 per cent of this carbohydrate market by volume.

Estimated price and income elasticities obtained with the traditional single equation approach and a systems method do not differ markedly. However, because of the interdependence between consumption of carbohydrates, the use of a systems method seems to be more appropriate. The consumption of maize meal is determined by the real potato price and the real income per capita index. The price of maize meal had no statistically significant effect on the consumption of maize meal, even when the variable was forced into the model. The consumption of bread is affected by the real white bread price, the real brown bread price, the real rice price and the real per capita income index, while potato consumption is affected by the real potato price and the real price of white bread. Bread consumption was influenced mainly by relative white and brown bread prices, and high price elasticities indicate the substitution effect.

Table 1: Different reported income and price elasticities of demand for carbohydrates in South Africa by source, 1983 - 1991

Commodity	Income elasticity	Source
Maize meal for urban blacks	0.06	Elliot & Van Zyl (1991)
Bread for urban blacks	0.11	Elliot & Van Zyl (1991)
Bread for urban blacks	-0.06	Nieuwoudt (1990)
Potatoes for urban blacks	0.14	Elliot & Van Zyl (1991)
Rice for urban blacks	0.16	Elliot & Van Zyl (1991)
Maize meal for rural blacks	0.20	Elliot & Van Zyl (1991)
Bread for rural blacks	0.23	Elliot & Van Zyl (1991)
Potatoes for rural blacks	0.16	Elliot & Van Zyl (1991)
Rice for rural blacks	0.16	Elliot & Van Zyl (1991)
RSA bread	-0.12	Niebuhr (1991)
RSA brown bread	-0.29	Niebuhr (1991)
RSA maize meal	-0.13	Van Zyl (1990)
Commodity	Own price elasticity	Source
RSA bread	-0.20	Darroch (1983)
RSA bread	-0.61	Elliott (1991)
RSA maize meal	-0.51	Frank (1986)
RSA maize meal	-0.13	Van Zyl (1985)
Urban maize meal	-0.70	Elliott (1991)
RSA white bread	-4.42	Niebuhr (1991)
RSA brown bread	-1.23	Niebuhr (1991)
Urban rice	-1.26	Elliott (1991)
Urban potatoes	-0.54	Elliott (1991)
RSA potatoes	-1.18	Bowmaker & Nieuwoudt (1987)

Table 2: Effects of relative prices and income on monthly national carbohydrate consumption estimated by single (Proc Stepwise) and simultaneous equations approaches, 1984-1990

Demand	Variable/statistics	Proc Stepwise	3SLS	
Maize meal	Intercept	0.5176**	1.137***	
	Potato price	0.111*	0.192**	
	Income index	0.012***	0.006**	
	F value	11.519		
	R ² value	0.422		
	DW statistic	1.553	1.529	
White bread	Intercept	-7.881***	-7.772***	
	White bread price	-2.674***	-2.574***	
	Brown bread price	1.244***	1.136***	
	Rice price	0.536***	0.479***	
	Income index	0.007**	0.006***	
	F value	336.517		
	R ² value	0.9418		
	DW statistic	1.584	1.532	
Brown bread	Intercept	-7.691***	-7.657***	
	White bread price	2.253***	2.173***	
	Brown bread price	-2.783**	-2.749***	
	Income index	0.007***	0.006**	
		F value	165.761	
	R ² value	0.8614		
	DW statistic	1.665	1.563	
Potatoes	Intercept	0.554***	0.639***	
	Potato price	-0.488***	-0.315***	
	White bread price	-0.292**	-0.289***	
		F value	21.997	
		R ² value	0.552	
	DW statistic	1.987	1.860	

Note: Significance level: * = 0.1; ** = 0.01; *** = 0.001.

The low elasticity coefficients estimated for the per capita income variable illustrates that carbohydrates are staple foods for consumers.

It can be concluded that relative real prices of carbohydrates and real income per capita play a major role in influencing which type of carbohydrate fulfils the required level of staple food satiation.

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