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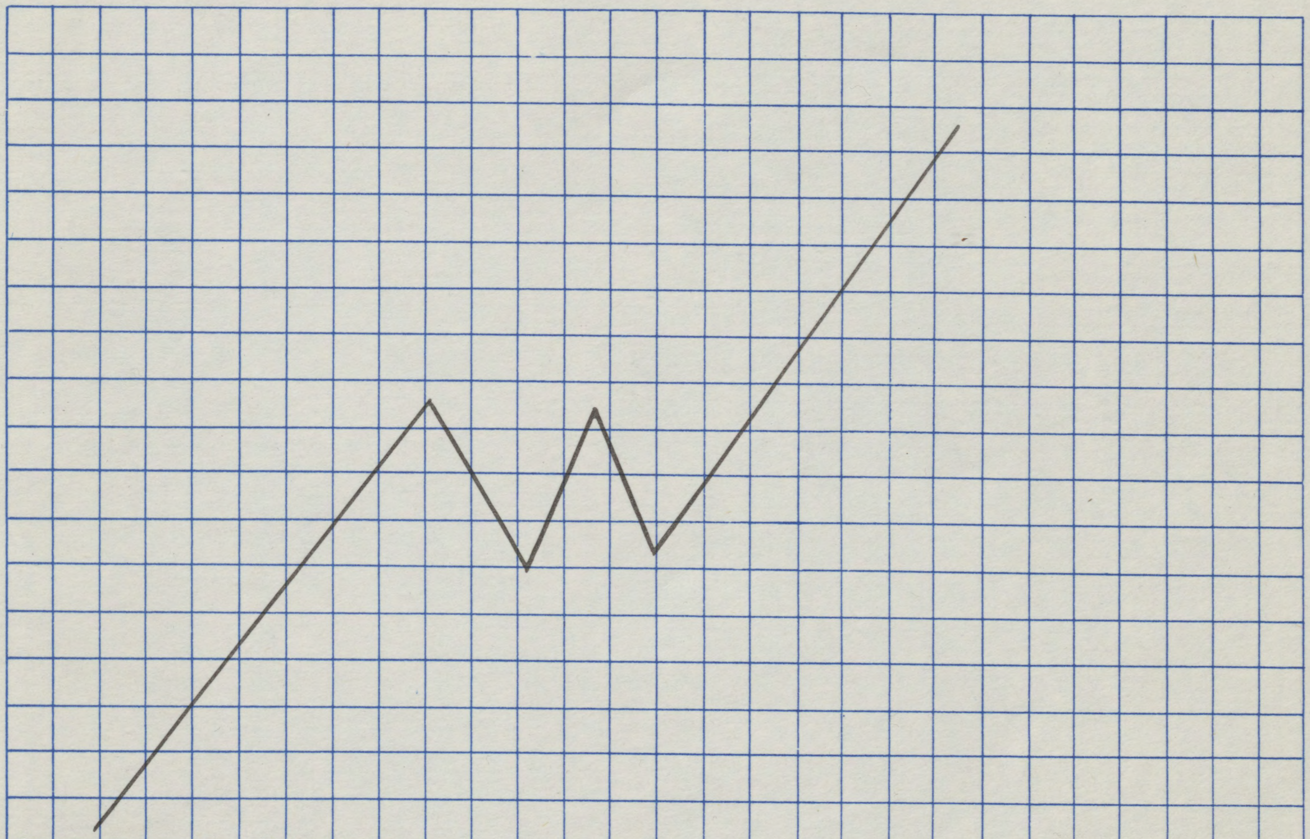

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DEMAND ANALYSIS OF VEGETABLES AND SUBTROPICAL FRUIT IN SOUTH AFRICA

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1. INTRODUCTION

This study is aimed at determining certain response coefficients (including price and income flexibilities and elasticities of demand) at the farm level for ten vegetables and four types of subtropical fruit in South Africa. The vegetables include tomatoes, onions, cucumbers, green beans, cabbage, gem squash, hubbard squash, pumpkin, sweet potatoes and potatoes, and the subtropical fruits considered are bananas, pawpaws, mangos and litchis. The study covers the 22-year period from 1958/59 up to and including 1979/80.

There appears to be a lack of research in the field of demand analysis of agricultural commodities in South Africa. Van der Merwe, for example, conducted an in-depth study of onion demand in 1968, and Broome a study on the demand for eggs and meat in South Africa in 1969. Similar analyses are now being undertaken by members of the Agricultural Policy Research Unit at the University of Natal. The results of this particular study may be useful for planning purposes and for decision-makers involved with the crops considered.

In section 2 the relationship between price flexibility and price elasticity of demand is discussed. This is followed by an explanation of the research procedure adopted and the results obtained.

2. PRICE FLEXIBILITY VERSUS PRICE ELASTICITY OF DEMAND

Estimating direct and cross-price flexibilities may be more appropriate in agriculture than measuring price elasticities of demand (Houck, 1965). For many agricultural commodities the quantities available for the market are fixed in the short run by the size of harvest. In other words, supplies to the market are determined in advance of current prices. Hence, for regression purposes price is taken as the dependent variable and quantity as one of the explanatory variables. The price flexibility coefficient therefore shows the percentage change in price associated with a one per cent change in the quantity demanded of that commodity, all other factors constant (The term, as used here, was introduced in 1919 by H.L. Moore (Houck, 1966, p. 225)). The price elasticity coefficient, on the other hand, measures the responsiveness of quantity to changes in the price of that commodity, other factors constant.

Meinken, Rojko and King (p. 734) have shown that the reciprocal of the direct price flexibility equals the direct price elasticity of demand only if cross flexibilites are zero. Houck (1965) has proved that, under general conditions, if significant cross effects exist the reciprocal of the direct price flexibility is less than the corresponding direct price elasticity. However, Colman and Miah argue that the proofs presented by Meinken *et al.* and Houck (1965) seem unacceptable because they confuse partial and total concepts of flexibility and elasticity. They point out that partial direct flexibilities and elasticities are inversely related "if there exists a linear relationship between two variables which can be correctly identified in both the statistical and economic senses ..." (p. 366). For one to be the inverse of the other, the coefficient of determination (R^2) must equal one (see Appendix 1). However, as this is never achieved in practice, the inverse of the price flexibility does not serve as a good estimate of the corresponding elasticity. Waugh (pp. 29-30) suggested that if the elasticity of demand is wanted for any reason then a regression equation having quantity as the dependent variable should be used.

3. RESEARCH PROCEDURE

With price as the dependent variable the following explanatory variables were considered in the regression equation:

(1) Consumption *per capita* in kg,
(2) real disposable income, and
(3) prices of crops that were considered to be either complements or substitutes.

With quantity consumed as the dependent variable, the price of the crop in question, real disposable income and prices of other goods were taken as independent variables. Prices of other crops are not necessary for determining price flexibilities or price elasticities of demand, but they are useful in improving the predictive qualities of demand equations. The more explanatory factors considered the greater the predictive value of a regression equation.

Most ot the statistics on the total quantities and values of vegetables and subtropical fruit produced in South Africa were obtained from the Abstract of Agricultural Statistics. Statistics not shown in the Abstract were obtained from the Division of Agricultural Marketing Research in

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Pretoria. Crop prices were determined by dividing the total value by the total quantity produced and consumed. Both prices and personal disposable incomes (which were obtained from the SA Reserve Bank Quarterly Bulletin) were deflated by the Consumer Price Index (CPI) with 1970 = 100. Population figures were obtained from the Abstract of Agricultural Statistics. From 1975 the population for South Africa and the independent homelands was estimated by projecting the Black population by 2,8 % per annum (based on the trend over the previous 10 years) and adding the numbers of the other three population groups. These figures were used to estimate *per capita* consumption for the various crops over the 22-year period considered. Based on the above data linear demand equations were derived using the least squares technique available on the Statistical Package for Social Sciences (SPSS). Tests for autocorrelation were based on the Durbin-Watson (d) statistic. Where the test proved inconclusive the regression equation was retained.

Autocorrelation problems were encountered with banana and mango data in the price-dependent equations, and with cabbage and sweet potato data where quantity was the dependent variable. In order to reduce autocorrelation time was included as an additional explanatory variable (value 1 to 22 for year 1 to 22, respectively) with the other variables unadjusted. (See the Frisch-Waugh theorem, e.g. in Maddala, p. 340.) After this adjustment the Durbin-Watson test showed no autocorrelation for sweet potatoes and mangos, and the test for bananas and cabbage was inconclusive.

In determining the final regression equations, which are presented in Appendices 2 and 3, all independent variables with associated t-values greater than one were retained. Haitovsky showed that the maximisation of the corrected multiple correlation coefficient R^2 is achieved by discarding all variables whose associated t-values are less than one.

4. RESULTS

Table 1 below provides a summary of the direct price flexibilities, price elasticities of demand and the income flexibilities and elasticities of demand for the crops studied. These are derived from the equations presented in Appendices 2 and 3 and the means given in Appendix 4.

All price flexibility and elasticity of demand coefficients are negative, indicating an inverse relationship between price and quantity. Comparing the flexibilities and elasticities, it is obvious that the reciprocal of the direct price flexibility would not serve a good estimate of the direct price elasticity of demand.

For onions a price flexibility of -2,36 means that if the quantity increases (decreases) by one per cent the price of onions would fall (increase) by 2,36 per cent. For bananas a one per cent increase in quantity would mean a 0,89 per cent fall in price. With regard to the elasticity of demand, a one per cent rise in the price of pumpkins would depress consumption by 0,12 per cent. It is of interest that all price elasticity coefficients, with the exception of mangos, are less than one, implying an inelastic demand for these commodities. The price elasticity coefficients of pumpkins and cabbage are relatively low, indicating that these crops are staple foods for the average person in South Africa. Increases in price have relatively little impact on the consumption of these commodities.

The price flexibility of income may be defined as the percentage change in price in response to a one per cent change in income, other factors constant. The income elasticity of demand is a measure of the responsiveness of quantity to changes in income, other factors constant (Tomek and Robinson). If, for a particular good, the quantity demanded falls as income increases it is termed an inferior good. From the above analysis inferior goods include green beans, pumpkin and pawpaws. They also include gem squash and sweet potatoes, as reflected in the negative income flexibilities. The negative income elasticity for pawpaws is a surprising result, as one would expect this crop to be a luxury.

Income flexibility and income elasticity of demand coefficients were not determined for certain crops, either because real disposable income had an associated t-value of less than one and was dropped from the analysis (for example, cabbage, pawpaws and litchis for the price-dependent equations, and gem squash and litchis for the quantity-dependent equations) or because the income variable was discarded owing to its high correlation with the time variable (r = 0,934).

Cross flexibilities and cross elasticities of demand can also be determined from the information given in Appendices 2, 3 and 4. The cross flexibility, in this study, would show the percentage change in price of commodity i associated with a one per cent change in the *price* of commodity j, other factors constant. (Normally the *quantity* of commodity j is considered.) The cross elasticity would reveal the responsiveness of the quantity of commodity i to changes in the price of commodity j, other factors constant.

5. CONCLUSIONS

This study was conducted in an attempt to determine response coefficients for certain vegetables and subtropical fruit in South Africa. The results were interesting in that the reciprocal of the direct price flexibilities would not yield good estimates of the corresponding price elasticities of demand. Manderscheid points out that for the successful interpretation of response coefficients the procedure adopted by the researcher should be known, since this will affect both the magnitude and the interpretation of the estimated coefficients. The user "who ignores these difficulties risks a misinterpretation of the estimated elasticity". (p. 136)

TABLE 1 - Direct price flexibilities, price elasticities of demand and income flexibilities and elasticities of demand for certain vegetables and subtropical fruit, South Africa, 1958/59 up to and including 1979/80

Crop	Price flexibility (Pf)	Price elasticity (Pe)	Income flexibility (If)	Income elasticity (Ie)
Tomatoes	-0,65	-0,77	0,12	0,76
Onions	-2,36	-0,33	2,34	0,96
Cucumbers	-0,22	-0,41	-	1,69
Green beans	-0,38	-0,89	-0,18	-0,59
Cabbage	-0,45	-0,21	-	-
Gem squash	-1,06	-0,60	-0,32	-
Hubbard squash	-0,31	-0,50	0,34	0,62
Pumpkin	-3,75	-0,12	-1,26	-0,28
Sweet potatoes	-1,33	-0,42	-0,88	-
Potatoes	-1,73	-0,42	1,45	0,84
Bananas	-0,89	-0,88	-	-
Pawpaws	-0,31	-0,70	-	-0,56
Mangos	-0,56	-1,27	-	-
Litchis	-0,48	-0,51	-	-

Annual data were used in the analysis. Monthly or quarterly data may give rise to better estimates of flexibility and elasticity coefficients since responses of price to quantity changes and vice versa are expected to be more sensitive than annual data will reveal. The results are, nevertheless, considered to be useful for policy planning purposes (for example, the use of price flexibilities to determine regional demand functions for inclusion in linear programming regional planning models) and the equations may be useful for their predictive qualities.

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Appendix 1

Price flexibility versus price elasticity

Given two equations:

$$Pi = a + bQi$$

and $$Qi = c + dPi$$

where Pi = price of commodity i

Qi = quantity of commodity i

a,c = intercepts

b,d = negative slope coefficients

Then, price flexibility (Pf) $= \frac{\delta Pi}{\delta Qi} \quad \frac{Qi}{Pi} = \frac{b.Qi}{Pi}$

and price elasticity (Pe) $= \frac{\delta Qi}{\delta Pi} \quad \frac{Pi}{Qi} = \frac{d.Pi}{Qi}$

In order for the reciprocal of Pf to be equal to Pe, d must equal 1/b or d.b = 1

i.e. $$\frac{1}{\frac{b.Qi}{Pi}} = \frac{d.Pi}{Qi}$$

$\therefore$ 1/b = d or b.d = 1

To test this, two equations were derived from the tomato data with only quantity or price as the explanatory variables.

TOMPR = 83,2406 - 1,8156 TOMCON R^2 = 0,1398 - (1.3)
(t = -1,80)

TOMCON = 15,0305 - 0,0770 TOMPR R^2 = 0,1398 - (1.4)
(t = -1,80)

It is obvious that the slope of equation (1.4) is not the inverse of the slope of equation (1.3). That is, the product of the two slopes (bd) is not equal to one, but equals 0,1398, which is the R^2. In other words, the product of the slope of the price-dependent equation and the slope of the quantity-dependent equation, with only quantity and price, respectively, as the explanatory variables, equals R^2. Hence d = R^2/b. Therefore, for d to be equal to 1/b, R^2 must equal one. This means that for Pe to be equal to the reciprocal of Pf, and with cross elasticities equal to zero, the R^2 must equal one. This result has been confirmed with other data.

Applying the above principle to the equations in Appendix 2 and 3 it was found that, in general, the higher the ration b.d/R^2 the closer the reciprocal of the price flexibility to the corresponding price elasticity coefficient.

Appendix 2

Presented below are the demand equations for vegetables (equations (2.1) up to and including (2.10)) and subtropical fruit (equations (2.11) up to and including (2.14)) for the period 1958/59 up to and including 1979/80, with *price* as the dependent variable.

(2.1) TOMPR = 66,2930 - 4,2213 TOMCON (t = -5,07) + 0,1116 REALY (t = 4,99)
R^2 = 0,63
d = 1,58
4-d = 2,42

(2.2) ONPR = 142,9521 - 33,1932 ONCON (t = -8,23) + 0,3875 REALY (t = 7,51) - 1,2371 TOMPR (t = -4,87)
R^2 = 0,82
d = 2,53
4-d = 1,47

(2.3) CUPR = 16,2946 - 19,4558 CUCON (t = 2,23) + 0,3229 TOMPR (t = 1,87) + 0,1454 LETPR (t = 1,12) + 0,7431 CABPR (t = 1,52)
R^2 = 0,61
d = 1,66
4-d = 2,34

(2.4) GRBPR = 92,1591 - 23,7524 GRBCON (t = -3,06) - 0,0372 REALY (t = -1,33) + 1,3010 CABPR (t = 3,36)
R^2 = 0,55
d = 1,82
4-d = 2,18

(2.5) CABPR = 18,9511 - 1,9774 CABCON + 0,1700 GRBPR
(t = -4,30) (t = 2,45)
R^2 = 0,65
d = 2,41
4-d = 1,59

(2.6) GEMPR = 80,0448 - 30,8424 GEMCON - 0,0367 REALY - 0,2785 PUMPR + 0,8539 HUBPR
(t = -5,92) (t = -1,89) (t = -1,48) (t = 2,71)
R^2 = 0,84
d = 1,21*
4-d = 2,79

(2.7) HUBPR = 22,6945 - 9,2938 HUBCON + 0,0324 REALY + 0,2035 PUMPR + 0,1447 SWPPR
(t = -2,53) (t = 2,39) (t=2,04) (t = 2,03)
R^2 = 0,63
d = 2,44
4-d = 1,56

(2.8) PUMPR = 151,1245 - 21,9108 PUMCON - 0,1039 REALY + 0,1043 POTPR + 0,7137 HUBPR
(t = -5,47) (t = -4,45) (t = 1,64) (t = 3,46)
R^2 = 0,77
d = 1,62
4-d = 2,38

(2.9) SWPPR = 97,1836 - 27,3420 SWPCON - 0,0931 REALY + 0,7746 HUBPR
(t = -4,71) (t = -2,86) (t = 2,29)
R^2 = 0,72
d = 1,73
4-d = 2,27

(2.10) POTPR = 28,7753 - 3,9128 POTCON + 0,2143 REALY + 0,4709 SWPPR + 0,7286 PUMPR
(t = -6,58) (t = 5,43) (t = 2,97) (t = 3,23)
R^2 = 0,80
d = 2,62
4-d = 1,38*

(2.11) BANPR = 120,8204 - 24,0784 BANCON + 2,3454 TIME
(t = -8,14) (t = 6,43)
R^2 = 0,78
d = 1,20*
4-d = 2,80

(2.12) PAWPR = 74,3806 - 20,4808 PAWCON + 0,0182 LITPR
(t = -2,83) (t = 1,28)
R^2 = 0,47
d = 1,82
4-d = 2,18

(2.13) MANPR = 120,6188 - 152,8549 MANCON + 3.8080 TIME
(t = -6,76) (t = 9,91)
R^2 = 0,86
d = 1,59
4-d = = 2,41

(2.14) LITPR = 136,9712 - 2726,8220 LITCON + 1,1063 BANPR + 1,5733 MANPR
(t = -2,92) (t = 1,71) (t = 3,72)
R^2 = 0,58
d = 2,02
4-d = 1,98

where TOMPR	=	tomato price	TOMCON	=	tomato consumption
ONPR	=	onion price	ONCON	=	onion consumption
CUPR	=	cucumber price	CUCON	=	cucumber consumption
GRBPR	=	green bean price	GRBCON	=	green bean consumption
CABPR	=	cabbage price	CABCON	=	cabbage consumption
GEMPR	=	gem squash price	GEMCON	=	gem squash consumption
HUBPR	=	hubbard squash price	HUBCON	=	hubbard squash consumption
PUMPR	=	pumkin price	PUMCON	=	pumpkin consumption
SWPPR	=	sweet potato price	SWPCON	=	sweet potato consumption
POTPR	=	potato price	POTCON	=	potato consumption
LETPR	=	lettuce price			
BANPR	=	banana price	BANCON	=	banana consumption
PAWPR	=	pawpaw price	PAWCON	=	pawpaw consumption
MANPR	=	mango price	MANCON	=	mango consumption

LITPR	=	litchi price	LITCON	= litchi consumption
REALY	=	real disposable income		
TIME	=	time factor		
d	=	Durbin - Watson statistic		
*	=	inconclusive d test		

Appendix 3

The equations below show the relationship between the quantity demanded, the dependent variable and the relevant explanatory variables for vegetables (equations (3.1) up to and including (3.10)) and subtropical fruit (equations (3.11) up to and including (3.14)) for the period 1959/59 up to and including 19/9/80.

(3.1)	TOMCON=	8,9494	-	0,1182 TOMPR (t =-4,29)	+	0,0207 REALY (t =6,09)	+	0,0190 ONPR (t =1,73)		R^2 = 0,76; d = 1,24*; 4-d = 2,76
(3.2)	ONCON =	3,6701	-	0,0238 ONPR (t =-8,23)	+	0,0113 REALY (t =12,63)	-	0,0313 TOMPR (t =-4,30)		R^2 = 0,92; d = 2,22; 4-d = 1,78
(3.3)	CUCON =	-0,0189	-	0,0046 CUPR (t =-1,68)	+	0,0026 REALY (t =7,03)	-	0,0025 LETPR (t =-1,17)		R^2 = 0,83; d = 1,54; 4-d = 2,46
(3.4)	GRBCON=	2,6935	-	0,0144 GRBPR (t =-3,06)	-	0,0020 REALY (t =-3,71)	+	0,0188 CABPR (t =1,67)		R^2 = 0,65; d = 1,39*; 4-d = 2,61
(3.5)	CABCON =	5,7598	-	0,0477 CABPR (t =-1,59)	-	0,0349 CAUPR (t =-1,77)	+	0,1192 TIME (t =9,16)		R^2 = 0,92; d = 1,28*; 4-d = 2,72
(3.6)	GEMCON=	2,0078	-	0,0208 GEMPR (t =-8,47)	+	0,0101 HUBPR (t =1,63)				R^2 = 0,79; d = 1,38; 4-d = 2,62
(3.7)	HUBCON=	1,4065	-	0,0168 HUBPR (t =-1,91)	+	0,0020 REALY (t =3,24)	-	0,0084 GEMPR (t =-2,24)		R^2 = 0,71; d = 1,34*; 4-d = 2,66
(3.8)	PUMCON=	6,6847	-	0,0208 PUMPR (t =-5,47)	-	0,0039 REALY (t =-8,50)	+	0,0041 SWPPR (t =1,47)	+	0,0093 GEMPR (t =3,26); R^2 = 0,95; d = 1,73; 4-d = 2,27
(3.9)	SWPCON =	3,0467	-	0,0206 SWPPR (t =-9,23)	-	0,0315 TIME (t =-12,88)				R^2 = 0,95; d = 1,89; 4-d = 2,11
(3.10)	POTCON =	6,0274	-	0,1835 POTPR (t =-6,58)	+	0,0548 REALY (t =11,37)	+	0,0898 SWPPR (t =2,47)	+	0,1401 PUMPR (t =2,70); R^2 = 0,93; d = 2,71; 4-d = 1,29*
(3.11)	BANCON=	4,3407	-	0,0323 BANPR (t =-8,14)	+	0,0932 TIME (t =8,92)				R^2 = 0,87; d = 1,19*; 4-d = 2,81
(3.12)	PAWCON=	2,1912	-	0,0107 PAWPR (t =-2,76)	-	0,0014 REALY (t =-3,70)	-	0,0015 BANPR (t = -1,36)		R^2 = 0,69; d = 1,19*; 4-d = 2,81

(3.13)	MANCON =	0,6534	-	0,0046 MANPR (t =-6,76)	+	0,0191 TIME (t =6,57)			R^2 = 0,73 d = 1,38 4-d = 2,62
(3.14)	LITCON =	0,0865	-	0,00009 LITPR (t =-2,53)	+	0,0003 MANPR (t =4,08)	-	0,0009 PAWPR (t =-1,92)	R^2 = 0,56 d = 1,60 4-d = 2,40

where abbreviated names are as in Appendix 2 and CAUPR = cauliflower price * = inconclusive d test

Appendix 4

The means of variables which were used in the demand equations are given below. These means were used in the calculation of the price and income flexibilities and elasticities of demand.

TOMPR	=	R65,0482 per tonne	TOMCON	=	10,0199 kg per capita
ONPR	=	R60,9795 per tonne	ONCON	=	4,3377 kg per capita
CUPR	=	R50,6991 per tonne	CUCON	=	0,5666 kg per capita
GRBPR	=	R77,5814 per tonne	GRBCON	=	1,2542 kg per capita
CABPR	=	R22,2105 per tonne	CABCON	=	5,0224 kg per capita
GEMPR	=	R42,7500 per tonne	GEMCON	=	1,4759 kg per capita
HUBPR	=	R35,2950 per tonne	HUBCON	=	1,1944 kg per capita
PUMPR	=	R30,2509 per tonne	PUMCON	=	5,1801 kg per capita
SWPPR	=	R38,7423 per tonne	SWPCON	=	1,8854 kg per capita
POTPR	=	R54,2268 per tonne	POTCON	=	23,9336 kg per capita
LETPR	=	R54,4814 per tonne			
CAUPR	=	R30,0741 per tonne			
BANPR	=	R78,3518 per tonne	BANCON	=	2,8840 kg per capita
PAWPR	=	R60,2168 per tonne	PAWCON	=	0,9253 kg per capita
MANPR	=	R105,7418 per tonne	MANCON	=	0,3838 kg per capita
LITPR	=	R262,7159 per tonne	LITCON	=	0,0467 kg per capita
REALY	=	R367,7273 per capita			