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RANDOM COEFFICIENTS ANALYSIS OF CHANGES IN MEAT CONSUMPTION PREFERENCES IN SOUTH AFRICA

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This study is designed to investigate changes in consumer preferences for meat in South Africa using Kalman random coefficients filtering techniques. The results provide substantial empirical evidence in support of notable changes in meat consumption patterns. The changes in meat consumption pattern can be attributed to changes in the prices of products. The empirical results indicate a long run growth prospect for white meat consumption. This study provides vital information for meat market analysis and projection of meat demand in South Africa.

1. INTRODUCTION

The South African economy faced various economic adjustments over the past two decades. Of relevance to this study, is the fact that income distribution as well as the levels of urbanisation have changed as a result of the fundamental political changes that recently took place in South Africa. For example, access to better education, health and other basic services for large numbers of previously disadvantaged citizens has increased. The nation of South Africa is becoming more urbanised and cosmopolitan. As a result, the structure and patterns of consumption have significantly changed. For instance, per capita consumption of red meats, particularly of beef decreased whereas consumption of poultry and pork increased over the past decade. The market share of beef in South Africa has declined to 25 per cent of total meat consumption since 1965/66, and the same holds for lamb (National Department of Agriculture, 2001).

The poor understanding of the determinants of changes in red meat demand in South Africa is certainly a contemporary research challenge. Previous studies of meat demand in South Africa have used the classical ordinary least squares with fixed-parameters over sample observations to estimate models. In the fixed-parameter estimation procedure the assumptions are too restrictive if there are large variations income and other economic variables. This might have generated misleading information for the meat industry

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about the changing economic conditions, thus leading to poor production planning. Thus providing information on expected demand while incorporating the dynamics of economic changes will facilitate better planning.

The purpose of this study is to analyse and measure changes in consumers' preferences for meat and consequent meat demand adjustments. The study used more appropriate econometric estimation techniques, namely the Kalman filtering method to conduct the intended analysis. That implies the use of the random coefficient estimation procedure to analyse changes in meat demand preferences by relaxing the constant coefficient assumption of a linear model to a randomly fluctuation across different observations. This research aims to provide a set of updated information on meat consumption pattern in the case of South Africa. Also it is intended to determine the changing pattern in meat consumption for improved policy design and formulation.

A description of the production and consumption patterns of meat in SA is presented in Section 2. Section 3 provides a review of the related literature. The empirical model is specified in Section 4. Results and interpretations are presented in Section 5 and Section 6 concludes the study.

2. MEAT CONSUMPTION PATTERNS IN SOUTH AFRICA

Per capita consumption of beef and veal has drastically decreased from a per capita consumption of 23.95 kg in 1965/66 to 12.32 kg in 1999/2000 (approximately 50% reduction). Per capita consumption of lamb reflects a similar pattern, down from 7.6 kg in 1965/66 to 3.8 kg in 99/00. On the other hand, per capita consumption of pork remained stable at about 3.0 kg over the same period. The aggregate per capita consumption of red meat (lamb, beef and veal, etc.) decreased from 34.42 kg in 1965/66 to 19.2 kg in 1999/00 (Table 1).

Table 1: Per capita consumption of meat in South Africa in kg (ten year average)

Period	White Meat	Red Meat
1971-1980	10	32
1981-1990	15	28
1991-1999	22	26

Aggregate per capita consumption of white meat however, increased from 2.98 kg in 1965/66 to 22.91 kg in 1999/00 (by about eight folds). This indicates a significant shift in meat consumption patterns. It is therefore of crucial importance for policy design to properly understand causes of this shift and the factors influencing meat demand in the country.

3. LITERATURE REVIEW

Previous studies for meat demand in South Africa were typically based on classical fixed parameters estimation procedure to estimate consumers' response parameters. For instance, Du Toit (1982) reported a long-run own price elasticity of -1.21 for beef. Hancock et al. (1984) reported that beef had an own price elasticity of -0.96, an income elasticity of +0.71, and the following cross price elasticities of +0.66, +0.72 and +0.19 for mutton, pork and chicken, respectively. Similarly, Bowmaker and Nieuwoudt (1990) estimated own price elasticity of -1.72 and income elasticity of +0.96 for beef. None of these studies tested for regularity conditions implied by demand theory on estimated parameters. Also these studies can be considered outdated due to the dynamic changes in the economic environment. Estimation procedures used in the said studies postulated constant elasticities over time and over all values of the exogenous variables. Although the constant elasticities' assumption is too restrictive, it is convenient for the estimation of the demand equation. This assumption can only hold over a short range of prices and income variability. Sometimes commodities that are luxuries become necessities when per capita income increases or the socio-demographic patterns change. Thus these estimated parameters need to be updated.

4. MODEL SPECIFICATION

Adjustments in demand due to own price changes imply movement along the demand curve whereas the entire demand curve shifts in response to changes in other commodities' prices, income and preferences (due to health reasons, etc.). For example the quantity of red meat purchased goes up or down along the red meat demand curve when the red meat price changes. However, if prices of red meat complements or substitutes (white meat) or consumers' income or preferences change, the entire red meat demand curve shifts. That will cause the red meat price to change for any red meat consumption level. In other words, that means adjustments in quantities demanded from red meat over time could be caused by changes in more than one determinant of red meat demand (i.e. both, movement along the demand curve as well as shifts in the demand curve position). Economists have long considered the time needed to adjust to income and prices changes to be an important aspect of

food demand. Consumers need more than a single period to make a full adjustment to these changes. Furthermore, the demand curve becomes more elastic in the long run than in the short run. A visual inspection of the per capita consumption over time without consideration of price or income shifts provides little information about meat demand. It is therefore important to estimate a demand function that can provide insight into preference' changes to gain proper knowledge of why the consumption pattern of red meat has changed. The effect of changes in prices and income on food expenditures depends on the price and income elasticities of demand. However non-economic factors such as dietary concerns can offset or accentuate the effect of economic factors on food consumption. Similarly, socio-economic factors such as family size and level of urbanisation have become important factors that influence demand for a commodity.

Following demand theory, per capita demand for meat can be expressed as a function of own price, prices of substitutes, and disposable personal income. Theoretically, the meat demand function can be characterized as:

$$Q_{it} = F(RPRM_i, RPWM_i, RINC_i, T) \quad (1)$$

Q_{it} is per capita consumption of the i^{th} commodity meat (i = red or white meat) in kg, $RPRM$ is the weighted average real price of red meat (beef and lamb) per kg, $RPWM$ is the real price of white meat (index), $RINC$ is real per capita income, T is the trend variable that reflects changes in consumers' taste and preferences resulting from increased awareness of health issues, among others. The assumption of including an exogenous time trend variable is a common method of treating change in preferences in demand relations (Johnson *et al*, 1984). The double log static equation for red meat takes the following form:

$$\text{Log } Q_{RMt} = \alpha + \beta_1 \text{Log}(RPRM) + \beta_2 \text{Log}(RPWM) + \beta_3 \text{Log}(RINC) + \beta_4 \text{log}(T) + \varepsilon_t \quad (2)$$

All prices and income are in real terms. Economic theory hypothesised that the signs of the coefficients in equation (2) should be: β_2 and $\beta_3 > 0$ and $\beta_1 < 0$ and that of β_4 depends on the commodity.

A common econometric procedure for estimating equation (2) is the classical ordinary least squares (OLS) with fixed parameters over the sample period. This assumption is, however, too restrictive. Our knowledge of numerous physical, economic and socio-economic factors that have an influence on food

demand and production is very limited. Our knowledge is even more limited with regard to the many interactive processes that take place among the above factors thus changing the structure of meat consumption preferences. Many factors such as taste, social factors, and health concerns that influence meat consumption have very limited predictability. Modelling the effect of such changes renders the classically estimated demand function inappropriate due to its inability to approximate the dynamics of changing economic variables. The change in the demand pattern and the large variation in income and prices create doubt about the estimates generated by the fixed coefficient OLS procedure. Random coefficient models are more adequate to study such changes in demand. This method allows the relaxation of the constant coefficient assumption in the linear model to randomly fluctuate across different observations.

Random coefficients regression was introduced by Quandt (1972) and subsequently extended by Cooley and Prescott (1974), Swamy and Mehta (1975) and Chavas (1983) and Gardade (1977). Swamy and Mehta (1975) and Cooley and Prescott (1974) have extended the single random coefficient method to the multi-regression model used the seemingly unrelated regression approach. Our study follows Chavas (1983) and Gardade (1977) in using the Kalman filtering techniques. The Kalman filter technique facilitates the estimation of preference changes from one period to another, which is not accounted for in the fixed coefficient regression models.

Kalman filtering techniques¹

Consider the following linear model $Y = X'\alpha + e$, where Y is a (Nx1) vector of N dependent variables, X is NxM matrix of independent observation, "α" is a Mx1 vector of the coefficients' matrix and $e \sim N(0, \sigma^2 I)$. The dynamic evolution of "α" vector is assumed to follow a random walk with zero drift through time for a specific dependent variable (Garbade, 1997), i.e., $\alpha_t = \alpha_{t-1} + \mu$, where $\mu_t \sim N(0, \sigma^2 \Omega)$ and μ is serially uncorrelated with e and Ω is the stationary covariance ratio matrix of innovation μ . If $\Omega = 0$, the above equation is nothing but the classical fixed coefficient model. If $\Omega \neq 0$, the parameter vector is random and thus structural change should be considered in the analysis. The random coefficients are estimated using the Kalman filter and maximum likelihood approaches. The Kalman filter is a recursive algorithm used for calculating linear least square forecasts of the state vector for given data, observed up to a given date say time "t" (Wegman, 1982). Random coefficients α_t are sequentially estimated, i.e., a_t and Σ_t is the covariance of the estimates

of α_t (Chavas, 1983). The Kalman filter provides the following sequential estimates of α_t and a_{t+1}

$$a_{t+1} = a_{t+1|t} + D_{t+1}(Y_{t+1} - X'_{t+1}a_{t+1|t}) \tag{5}$$

and

$$a_{t+1|t} = a_t \tag{6}$$

$$D_{t+1} = \Sigma_{t+1|t} X_{t+1} (X'_{t+1} \Sigma_{t+1|t} X_{t+1} + 1)^{-1} \tag{7}$$

$$\Sigma_{t+1|t} = \Sigma_{t+1|t} + \Omega \tag{8}$$

$$\Sigma_{t+1|t} = \Sigma_{t+1|t} - G_{t+1} X'_{t+1} \Sigma_{t+1|t} \tag{9}$$

$$\Omega = K^2 \Sigma_0 \tag{10}$$

Where K^2 is the ratio of the variance of the process noise to variance of the parameter estimate and D_{t+1} the gain filter. The problem now is that there is no *a priori* estimates of α_t and Ω to start the recursive estimation. Following, Gardade (1977), the algorithm can be initialized by using the first t observations, in our case the first five observations. As for Ω the variance ratio matrix and the variance σ^2 , they can be estimated by maximum likelihood approach (Garbade, 1977 and Abraham & Ledolter, 1983). So, once the starting values of α_0 and Σ_0 are known, then K and Ω can be calculated. If $K=0$, then $\Omega=0$ and $\alpha_{t+1} = \alpha_t$ in the random model and the parameters are constant. Alternatively, if K is not equal to zero, then $\Omega \neq 0$, which implies random coefficients due to structural changes from one period to another. The Kalman filter technique can potentially be used for estimating preference changes from one period to the next. This estimation technique can be implemented in numerous economic applications such as predictions, forecasts and marketing analysis.

5. DATA SOURCE

This study is based on annual data on meat consumption between 1970 and 1999. Data on per capita consumption was obtained from the "Abstract of Agricultural Statistics" published by the National Department of Agriculture and the South African Meat Industry Council. The consumer price index (CPI) and disposal income were obtained from the International Financial Statistics

(IFS), a publication of the International Monetary Funds. However, the numbers do not reflect the total meat consumption for South Africa due to informal slaughtering, which is believed to be substantial and which could have an important impact on per capita consumption figures. Until a study which will estimate the informal slaughtering and meat trade is conducted, we have no choice but to use the official statistics published by the National Department of Agriculture.

6. ESTIMATION AND EMPIRICAL RESULTS

The following equations for red and white meat demand were estimated simultaneously using the Kalman filtering technique performed in SAS version 8:

$$\text{Log } Q_{\text{RMt}} = \alpha_{11} + \beta_{11} \text{Log RPRM}_t + \beta_{12} \text{Log RPWM}_t + \beta_{13} \text{Log RINC}_t + \beta_{14} \text{log } gT + \mu_t$$

$$\text{Log } Q_{\text{Wmt}} = \alpha_{21} + \beta_{21} \text{Log RPRM}_t + \beta_{22} \text{Log RPWM}_t + \beta_{23} \text{Log RINC}_t + \beta_{24} \text{log } gT + \varepsilon_t$$

The estimates of the parameters are reported in Table 2. Regression F-ratio and the coefficients are statistically significant, DW and the correlation matrix indicated the absence of correlation in the residuals and also the absence of multi collinearity. The constant term is interpreted as a normalised scaling parameter so that the negative sign does mean negative consumption.

Table 2: Estimated results

	Red Meat		White Meat
α_{11}	5.0199 (7.0508)*	α_{21}	-2.5463 (-1.6832)***
β_{11}	-0.4122 (-1.6422)***	β_{21}	0.27514 (1.6428)***
β_{12}	0.8762 (1.9837)**	β_{22}	-0.9442 (-3.3600)*
β_{13}	-0.02656 (0.2389)	β_{23}	0.7417 (2.3880)
β_{14}	-0.2185 (-1.6658)**	β_{24}	0.3239 (6.5327)
D.W	1.81	D. W	1.79
Adjusted-R-Square	0.76	Adjusted R-Square	0.91
Period	1973-1998	Period	1973-1998

t-statistics are in parenthesis. * significance at 1%, ** significance at 5% and *** significance at 10%

These results give information on price elasticities and consumption growth. The model results indicate that red meat has a price elasticity of -0.41, and white meat is a significant substitute for red meat, with a cross price elasticity of 0.8762. The results support the fact that red meat demand is not statistically responsive to changes in total per capita expenditure. It appears that beef demand did not benefit from changes in consumer expenditure patterns, but white meat did. The negative elasticity associated with the time trend indicates a negative consumer preference for beef. White meat has an own price elasticity of -0.94, and thus demand is highly responsive to price changes. The cross price elasticity of 0.27, implies that the demand for white meat is not highly responsive to change in red meat price. Income has significant impact on white meat consumption, thus growth in income will significantly alter the consumption pattern of white meat. The parameter associated with the time trend indicates that the consumer has developed an acquired preference for white meat.

Red and white meat consumption has gone through various stages of structural changes for the estimation period. These are reflected in own price elasticity. In the case of red meat there are four structural changes in the periods 1980 to 1981, 1982 to 1983, 1984 to 1988, and 1989 to 1998. Whereas in the case of white meat structural change occurred in the periods 1980 to 1984, 1985 to 1988 and 1989 to 1998. For the period 1980 to 1998 the growth rate of red meat consumption has decreased at a decreasing rate from a 32.5 % (1980) to -2.2 % (1998). Whereas in the case of white meat consumption the growth rate has increased at an increasing rate from -18.6% (1980) to 5.6%(1998).

Tables 3a and 3b report annual estimates of the elasticities and consumption growth rate for red and white meat. From Table 3a, it is apparent that between 1984 and 1989 the price elasticity of red meat had a positive sign but is small in absolute terms. This is against economic theory and is somewhat puzzling. A possible explanation could be related to the fact that the price data used were the Meat Board auction prices and not retail prices - which are usually very difficult to get. Consumers usually react only on the retail prices and the way that retailers transmitted price increases and price decreases differed. In order to avoid a drop in sales the full increase in auction prices was not transmitted to consumers leading to the possible positive relationship between the increase in auction prices and quantity consumed. When prices dropped, the consumer also did not receive the full benefit of the price decrease due to retailers trying to capture the lost rents during the upward trend in prices.

The estimated income elasticity though is statistically insignificant, has a negative sign in the case of red meat, which implies that red meat may be considered as an inferior good. From 1989 onwards, both direct and cross price elasticities have the proper sign but income elasticity still kept the negative sign. This provides some indication that there was a structural change in red meat consumption, which is also evident from Table 3b where the sign changes from positive to negative for the cross price elasticities for the same period. The time trend is another indicator of growth in consumption. For red meat, it had an associated elasticity of 3.25 and it decreased to -0.215, whereas, white meat started with a negative value of -1.857 and increased to 0.511. This provides an indication that red meat consumption will decrease further with time and white meat consumption will increase with time *ceteris paribus*.

Table 3a: Yearly parameter estimates for red meat

YEAR ²²	α_{11}	β_{11}	β_{12}	β_{13}	β_{14}
1980	1.707	1.633	0.380	-3.949	3.245
1981	2.887	0.554	0.231	-1.560	1.314
1982	3.611	-0.054	-0.051	-0.182	0.179
1983	3.578	-0.031	-0.042	-0.226	0.216
1984	3.473	0.019	-0.060	-0.292	0.274
1985	3.263	0.123	-0.064	-0.464	0.430
1986	3.382	0.090	-0.007	-0.495	0.456
1987	3.402	0.105	-0.035	-0.586	0.540
1988	3.352	0.132	-0.064	-0.642	0.594
1989	3.736	-0.013	0.014	-0.492	0.442
1990	4.395	-0.251	0.184	-0.306	0.248
1991	4.608	-0.323	0.199	-0.229	0.164
1992	4.674	-0.346	0.209	-0.215	0.149
1993	4.682	-0.349	0.219	-0.227	0.163
1994	4.485	-0.268	0.058	-0.299	0.236
1995	4.469	-0.251	0.151	-0.266	0.178
1996	5.218	-0.509	0.694	-0.114	-0.007
1997	5.230	-0.489	0.816	-0.019	-0.151
1998	5.020	-0.412	0.876	-0.027	-0.219

Table 3b: Yearly parameter estimates for white meat

YEAR	α_{21}	β_{21}	β_{22}	β_{23}	β_{24}
1980	1.127	-0.893	-0.822	2.539	-1.857
1981	1.112	-0.994	-0.835	2.762	-2.036
1982	1.186	-0.273	-0.501	1.126	-0.689
1983	1.152	-0.171	-0.462	0.922	-0.520
1984	0.987	-0.042	-0.507	0.755	-0.373
1985	0.789	0.160	-0.515	0.421	-0.070
1986	1.215	0.057	-0.338	0.325	0.013
1987	1.247	0.063	-0.349	0.288	0.047
1988	1.235	0.090	-0.378	0.232	0.101
1989	1.116	0.151	-0.411	0.169	0.166
1990	1.015	0.197	-0.444	0.133	0.203
1991	1.038	0.187	-0.442	0.144	0.191
1992	0.808	0.279	-0.486	0.086	0.255
1993	0.865	0.269	-0.455	0.046	0.301
1994	0.880	0.260	-0.438	0.054	0.293
1995	0.924	0.247	-0.511	0.027	0.340
1996	0.559	0.399	-0.831	-0.062	0.449
1997	0.606	0.388	-0.897	-0.113	0.526
1998	0.699	0.360	-0.918	-0.130	0.551

The empirical results indicate that a major shift has occurred in demand for meat, red and white meat. In the case of red meat it, can be attributed to prices of competing meat mainly chicken prices since chicken is a highly significant substitute for beef. From Table 3b, given a 1 percent increase in the price of red meat, the change in white meat consumption is much more than for a given 1 percent change in the price of white meat. These estimates indicate the importance of relative prices and that the per capita consumption of red meat is highly responsive to prices of white meat. When compared to the demand for white meat the price of red meat is less responsive. Hence, the increase in consumption for white meat can be attributed partly to the changes in red meat prices that cause consumer to substitute red meat for white meat.

Another issue that can explain this structural change may be the changing demographics of South Africa. Also it may due to the fact that after the change in the political regime South African have much more freedom of movement, leading to a decline in the time allocated to food preparation at home. Assuming consumer's demand for "convenience" food has increased, this may have benefited the poultry sector over time by offering products that are

²² The estimates of year (t) can be used to forecast demand of year (t + 1).

more convenient and easier to prepare compared to beef and lamb. At the same time, red meat demand may have suffered because of the longer time needed for preparation and that the red meat industry failed to provide consumer quality, convenience, and easy to prepare meat products. Finally, it is apparent from above that a shift in meat consumption patterns has occurred leading to a preference for white meat over red meat.

6. CONCLUSIONS

Important changes have been observed in meat consumption in South Africa. Per capita consumption of white meat has increased whereas the opposite happened to red meats. The present study adopted the random coefficient estimation procedure to investigate changes in consumers' meat preferences. The results provided strong evidence in support of important changes in consumers' preferences for meat while explaining high substitutability between red and white meat. The changes in consumption pattern can be attributed to the changes in income distribution, changes in real meat prices and level of urbanisation, which may have resulted in a change in consumer preferences.

A few lessons can be drawn from the analysis. First, the results confirm the need for the red meat industry to commit resources to research and development of innovative and consumer friendly, easy to prepare beef items suitable for sale in retail shops. Second, the industry must recognise that as consumers place a higher value on their time, the demand for food that requires less preparation time will increase. Finally, this research determined the consequences of changes in prices of white meat and income on demand for red on a yearly basis. Future studies of demand for meat should consider evaluating the impact of consumer meat expenditure and changing consumer demographics as well as the very important issue of food safety.

NOTE

1. For extensive surveys of the application of time varying coefficient model (state space model) the reader can refer to Hamilton (1994a), Harvey (1989) and Brown and Lee (1992).

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