RECENT CHANGES IN THE RELATIONS OF BRAZILIAN MEAT DEMAND

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ABSTRACT - The Brazilian meat demand system was analyzed from 1990 to 1997, focusing on the relationship between beef, pork, and chicken meat in terms of substitutability relations. Changes in demand arose from the increase in consumption of high value-added products and prepared food from self-service restaurants and fast food chains. A model of seemingly unrelated regressions was proposed for the analyses of the meat demand system because it is appropriate and has never been used in Brazil. The results show that meat demand is price-inelastic and income-inelastic. The cross-price elasticities indicate that pork is a substitute for beef, and chicken is a complement to both beef and pork.

Key words: Meat demand system, price-elasticity, cross-price elasticity, consumption, Brazil.

INTRODUCTION

Brazilian meat demand inter-relations have not been investigated since the mid- 1980s. Up until then, beef, chicken and pork meats were considered substitute products according to Brandt (1980) – 1947 to 1970, Silva et al. (1977) – 1969 to 1974, and Fernandes et al. (1989) – 1964 to 1985.

Since the mid 1980s, there has been an overall trend toward increased consumption of processed meals and eating out, a consequence of the growing number of working women, who have less time available to prepare meals, the global restructuring of the food industry as it adapted

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to new eating habits, and an expanding consumer preference for processed food. This gave rise to matricial consumption, i.e., eating options were multiplied due to market segmentation, creating a spectrum of differentiated lines for each type of product to meet changing consumer profiles and food market niches (Martinelli Jr., 1997; Santana, 1997; Park & Capps Jr., 1997). This global phenomenon has been abetted by fast food restaurants and self service chains, which not only encourage eating out but have made it a viable experience. As a result, the cross relations of meat demand must have been altered. According to recent evidence, chicken meat is now a complement to pork in the United States and Canada (McNulty & Huffman, 1992; Moschini & Vissa,1993), to mutton in Australia (Park et al., 1996), and to imported beef and pork in Japan (Hayes et al., 1990). A similar phenomenon is expected to take place in Brazil, since such changes tend to occur on a worldwide basis.

As evidence of this trend, over the last six decades, the time spent preparing food at home has declined worldwide, from 130 minutes per day in 1930 to 15 minutes per day in 1994 (Agrianual, 1999). In the state of São Paulo, Brazil, in 1995/96, processed food expenditures were 3.5 times higher than *in natura* food expenditures among households earning over 20 minimum wages (MW) and 2.4 times higher among households earning from 5 to 20 MW (Table 1). In Brazil, the most popular eating places serving meat are fast food, self-service, and barbecue style restaurants.

As the time spent in meal preparation has decreased and the habit of eating at home has weakened, processed food consumption has grown across all income classes while *in natura* meat expenditures have dropped (Table 1). Note that even when food is consumed at home, preference is given to processed food often containing more than one type of meat. Park & Capps Jr. (1997) found a complementarity between processed food and other types of food.

Increasing consumption of processed food has led Brazil's poultry industry to diversify production, and the industry has reached the forefront in meeting consumer needs. Between 1990 and 1997, Brazilian consumption of chicken increased 77.61% (from 13.4 to 23.8 Kg/person/year), rising 2.4 times faster than pork consumption (from 6.9 to 9 Kg/person/yr, a 30.43% increase) and 5.88 times faster than beef consumption (from 31.8 to 36.0 Kg/person/yr, a 13.21% increase) (Anualpec, 1998; Agroanalysis, 1998). Applying these Brazilian meat market data, one can assume chicken to be a complement to beef and pork.

Table 1 – Food expenditure of São Paulo households, according to income class

Expenditure categories	Low income up to 5 MW	Medium income from 5 to 20 MW	High income 20 and up MW
Food expenditure	33,52%	24,10%	16,69%
Food-away-from-home	3,82%	5,61%	5,53%
Food at home	29,70%	18,50%	11,16%
In natura food	9,73%	7,10%	3,71%
Processed food	23,79%	17,00%	12,98%
In natura food meat	5,02%	4,07%	1,99%
Beef	3,65%	3,00%	1,56%
Pork	0,07%	0,16%	0,05%
Chicken	1,29%	0,92%	0,37%

Source: IBGE (1997). MW = minimum wages.

Table 1 shows figures that confirm Engel's Law, which states that the ratio of income spent on food decreases as income increases. São Paulo's low-income households spend 33.52% of their income on food whereas medium income households spend 24.10% and high income households spend 16.69% (Table 1). This tendency is also found in the United States where low income households spend 49% of their income on food, medium income households spend 24% of their income on food, and high-income households for the spend 16% of their income on food (McDowell et al., 1997).

In recent study on food consumption trends for the year 2020, Rosegrant & Sombilla (1997) show that in the period between 1997 and 2020, real prices of food should fall more rapidly than global food demand and food consumption in the developing countries could increase. This is a sign that food safety will improve among the poorer classes and that a matricial consumption pattern may be consolidated worldwide. This is another reason to put forward the hypothesis that mixed demand functions in Brazil have indeed changed.

Objective

The overall objective of this work is to analyze the behavior of cross-relations in the Brazilian meat demand system from 1990-1997.

When faced with a negative cross-elasticity for meats and other products, products said to be "substitutes" *a priori*, demand studies will characteristically and without exception state only that the result found is not in agreement with the expected result. Our research intends to go further, by presenting theoretical foundations to evaluate the recent changes in consumption behavior and by proposing an empirical model to highlight those changes.

This specific objectives of this research are:

a) to estimate price-elasticities and income-elasticities of beef, chicken, and pork in Brazil;
b) o evaluate the mixed elasticity changes between beef, chicken, and pork by comparing the period from 1990-1997 with the period before 1990, and with recent data from other countries;
c) to present suggestions to Brazilian decision makers.

THEORETICAL MODEL

The economic relations among commodities, known in the literature as complementarity and substitutability relations, are presented in textbooks and technical papers with absolute acceptance. The idea is simple: complementary commodities are those in which consumption variation tends to be parallel, such as coffee and sugar (Santana & Silva, 1998) and substitutive commodities are those whose consumption tends to vary inversely, such as coffee and tea, pencils and pens. In Brazil, beef and chicken meat were found to be substitutive commodities until the mid 1980s (Fernandes et al., 1987) and, more recently, in the Brazilian state of Pará (Santana, 1998).

Although simple, this idea is very imprecise. Complementary and substitutive goods imply two distinct concepts: perfect complementarity or substitutability and imperfect complementarity or substitutability. Perfect complementarity is consumption in fixed ratios and the indifference curves are rectangular, as is the case of right and left shoes.

Shoes and socks are a good example of imperfect complementarity, since the shoes can be worn without the socks. Perfect substitutability is equiproportionally inverse consumption in which the indifference curves are straight lines, e.g., blue and black pencils, at least for consumers to whom color is not important. Imperfect substitutability is consuming pencil and pen.

The correct idea for economic identification of complementary goods is that consumption of products (X and Y) must vary towards the same direction in response to specific causes, such as price, which must be duly identified before any judgment is made. Besides being a difficult task, this may demand a fair amount of arbitrariness in the process of correctly determining such economic relationships.

The classical definition of complementarity and substitutability is given by Edgeworth (Simonsen,1987). Two commodities, e.g., X and Y, are said to be a complement of each other when increasing the amount of X, causes Y's marginal utility to also increase; they are said to be a substitute for each other when by increasing X, Y's marginal utility is caused to decrease. This definition is derived from the sign of the partial second order derivative of a given utility function: $u = u(x, y)$

$$u_{xy} = \frac{\partial^2 u}{\partial x \partial y}$$

if $u_{xy} \succ 0$, the goods are said to be complements. If $u_{xy} \prec 0$, the goods are said to be substitutes.

This definition has two important properties. The first concerns the incorporation of the intuitive conception of complementarity and substitutability relationships. The second is the property of symmetry, supported by the fact that, if X substitutes (complements) Y, Y also substitutes (complements) X.

In this regard, Hicks has reached a conclusion which even today is widely accepted (Simonsen, 1987) by stating that two commodities are substitutes when the substitution mixed effects are positive,

$$(\partial x_i / \partial p_j)_{u=constant} \succ 0$$

and they are complementary when these effects are negative,

$$(\partial x_i / \partial p_j)_{u=constant} \prec 0$$

Here the fundamental identified cause would be the price increase of one of the goods followed by a compensatory income rise, sufficient for the consumer to reach the same indifference curve surface.

Didactically, it is understood that meat demand is based on consumer theory and it is derived from the optimum solution of a problem of consumer preference maximization in relation to a given price and income level, as in the following (Varian,1984):

$v(p,r) =$	$\max : u(q)$
	$s.a. \quad p \cdot q = r$

where $v(p,r)$ is an indirect utility function and represents the maximum utility found for a given price p (price vector of n products) and income levels r. The indirect utility function is obtained by substituting the demand equations as a function of direct utility $u(q)$ to obtain: $v(p,r) = u[q(p,r)]$. The quantity q that optimizes the problem is seen as that which maximizes the consumer's desire for given price and income levels; and the function relating them is called Marshallian demand function, represented by $q=q(p, r)$.

An important property of the indirect utility function is the establishment of an identity between the Marshallian demand function (or ordinary demand) – obtained from the maximization of the utility function subject to price and income - and the Hicksian demand (or compensated demand), derived from minimization of the consumer's budget subject to the utility function given by:

$$q_m(p,r) = q_h[p, v(p,r)]$$

Since compensated demand is not directly observable because it depends on utility and since ordinary demand, expressed in income and price, is observable, the advantage of such an identity is that it makes possible, by the use of the latter, to carry out the same empirical analyses of the former.

The assumptions attributed to the individual consumer in an attempt to optimize his/her decisions are overall valid for the Marshallian aggregate demand, at least as a necessary condition as far the principles of degree zero continuity and homogeneity are concerned. Since the aggregate function does not necessarily inherit the theoretical restrictions of homogeneity and Slutsky Symmetry, it becomes more adequate to represent the cross-relation of demand than the compensated demand by assuming that the products are substitutes, as Hicks acknowledged that goods tend to be substitutive rather than complementary. Hence, a Marshallian meat demand system will be applied in Brazil.

Finally, the substitutability and complementarity relationships may be illustrated by taking a function of Marshallian demand defined as follows:

$$q_x = f(p_x, p_y, r)$$

in which q_x, p_x, p_y, r = are product X's demanded quantity, product X's price, product Y's price and consumer's income, respectively. Products are said to be substitutes if the cross effect between X and Y is positive, and complementary if this effect is negative, as follows:

Substitute: $$\frac{\partial q_x}{\partial p_y} \succ 0$$

Complementary: $$\frac{\partial q_x}{\partial p_y} \prec 0$$

In the first case, X demand increases as Y price increases; in the second case, demand decreases. One should observe that in the case of two products, the concept is easy to understand; but it becomes troublesome when applied to more general situations involving more than two products. In this case, it is possible for product X to be a substitute for product Z and for Z to be complementary to X, violating the property of symmetry.

Beef, chicken, and pork, as previously mentioned, are the three main sources of protein in Brazil. These products are initially expected to be imperfect substitutes since they are sources of protein and can be consumed individually. However, due to the recent trend toward eating out at self-service restaurants, fast food chains, and barbecue houses and increasing consumption of processed food at home, where these types of meat are served together, symmetry might be violated. Hence, both consumption relationships can be found in Brazil. The economic relationship between these three sources of protein will be empirically analyzed in order to clarify their association.

ECONOMETRIC MODEL

In Brazil, meat demand relations have been studied by means of uniequational models and simultaneous models of supply and demand (Silva et al. 1997, Brandt, 1980, Santana, 1988). On the other hand, Fernandes et al. (1989) applied the Rotterdam model for the meat demand system, which is considered the ultimate comprehensive study in this area. Recent international works have applied differentiated and/or combined models, involving the Hicksian, Marshallian, and Rotterdam demand systems and even the ideal Deanton system (Hayes et al., 1990; Moschini & Vissa, 1993; Park et al., 1996; Piggott et al., 1996).

All these works are mostly concerned with a trivial analysis of the results from the viewpoint of neoclassic theory and/or with offering some contribution or innovation in the mathematical formulation of the proposed models. On the other hand, there is an overall lack of interest in investigating the economic causes that support the evidence from these research results, results which contradict the standard norms of the theoretical jargon. In this work, the opposite is intended, as it begins with an analysis of the economic facts to reach an adequate model and to make reality evident.

The econometric model proposed to represent the beef, chicken, and pork demand equations is a system of seemingly unrelated equations, which is being applied for the first time in Brazil. A justification for the use of this model is that the error term of at least one of the meat demand equations is correlated with the error terms of the remaining equations. If this hypothesis holds true, then the separate estimate of each equation does not take into account the information about the mutual correlation of the error terms, and the efficiency of the estimators becomes questionable (Kmenta, 1978). The error terms are also assumed to be autocorrelated. This is another justification for applying the method of generalized least squares (GLS) to the system of equations because it increases the efficiency of estimators.

The overall specification of the system of seemingly unrelated regressions (SUR), including the hypothesis of autocorrelation of residuals is the following:

$$Q_{it} = P_{it}\beta_i + \varepsilon_{it}$$
$$\varepsilon_{it} = \rho_{i1}\varepsilon_{it-1} + \rho_{i2}\varepsilon_{it-2} + \dots + \rho_{ij}\varepsilon_{it-j} + u_{it}$$
$$t = 1,2,\dots,T; i = 1,2,\dots,N$$
$$E(\varepsilon_t\varepsilon'_t) = \Omega; \varepsilon'_t = (\varepsilon_{1t}, \varepsilon_{2t},\dots, \varepsilon_{NT})$$
$$u_{it} \sim N(0,\sigma^2)$$

in which:

Q_i = is the vector of endogenous variables, representing the quantities of beef, chicken, and pork demanded in tons per month;

P_i = is the vector of exogenous variables, representing the prices of beef, chicken, and pork in (R$/T) and consumer income (R$);

ε_i = is the vector of residuals, generally assumed as independent, which, in this case, may present current cross-correlation among the equations.

The SUR Model estimate is easily carried out in three steps, as follows (Maddala, 1988; Greene, 1997):

1. each S.U.R. model equation is estimated by means of ordinary least squares (OLS), and the consistent estimator of ρ is used to transform

each equation and to correct autocorrelation;;

2. OLS residuals are used to estimate the matrix of variance and covariance Σ;
3. SUR is re-estimated by GLS by using the transformed data and the Σ matrix.

Initially, the matrix of variance and covariance of the SUR error terms given by

$\Omega = \Sigma \otimes I$, is not known but it can be estimated by using the values obtained when estimating OLS, for the matrix $\hat{\sigma}_{ij}$, which is the estimator of Σ.

$$\Sigma = \hat{\sigma}_{ij} = \hat{s}_{ij} = \left((\varepsilon'_i \varepsilon_j)/\max(T_i, T_j)\right)$$

The vector β of GLS is given by :

$$\beta_{MQG} = \left(P'(\Sigma^{-1} \otimes I)P\right)^{-1} \cdot \left(P'\,(\Sigma^{-1} \otimes I\,) \cdot Q\,\right)$$

The estimate of GLS the vector β of GLS, obtained through use of Eviews software, combines the two systems of equation into another, non linear system, as follows:

$$Q_{it} = P_{it}\beta_i + \rho_{i1}(Q_{it-1} - P_{it-1}\beta_i) + \ldots + \rho_{ij}(Q_{it-j} - P_{it-j}\beta_i) + \varepsilon_{it}$$

At each step, Eviews estimates the equation by nonlinear least squares (NLS) to obtain the variance--covariance matrix of residuals, to construct matrix Σ, and to complete the first interaction. This process continues until all the coefficients meet. Estimation is done by the full information maximum likelihood method.

The hypotheses of price-elasticity symmetry and homogeneity of degree zero for income-elasticity and degree zero for price and income will be tested prior to SUR estimation. It must be made clear that such properties are not required for the aggregate demand system, hence the need for the test.

Symmetry hypothesis:

$H_0 : \eta_{ij} = \eta_{ji}$ e $H_a : \eta_{ij} \neq \eta_{ji}$; $i \neq j$, (i, j = beef, chicken, pork)

Income homogeneity hypothesis

$H_0: \sum \eta_{ri} = 1$ e $H_a: \sum \eta_{ri} \neq 1$

Income and price - elasticity homogeneity hypothesis

$$H_0: \sum_{j=1}^{n} \eta_{ij} + \eta_{ri} = 0 \text{ e } H_a: \sum_{j=1}^{n} \eta_{ij} + \eta_{ri} \neq 0$$

When such restrictions are included, the SUR system is called a restricted model and when without restrictions, an unrestricted model. Before estimating the restricted model, symmetry and homogeneity hypotheses will be submitted to the Wald test (Judge et al., 1985, Greene, 1997) to verify their convenience.

The null and alternative hypotheses to be tested can be represented as:

$$H_0: R\beta = r \text{ and } H_a: R\beta \neq r$$

The R vector has dimension (m x k) and the r vector dimension (m x 1) in which m is the number of restrictions and K is the number of equation parameters. Under symmetry restriction, m equals 3 and under homogeneity restriction, m equals 1. Wald statistics are given by Judge et al. (1985)

$$\lambda_w = \frac{[(e'_r \Omega^{-1} e_r) - (e'_i \Omega^{-1} e_i)]}{\sigma_i^2} \xrightarrow{d} \chi^2_{(m)}$$

in which:

$e_r = Q - P\beta_r$ relative to the restricted model

$e_i = Q - P\beta_i$ relative to the unrestricted model

The Marshallian meat demand equation system to be estimated for Brazil over the 1990-1997 period, including a dummy variable (DV) - to capture the seasonal effect between the crop and inter-crop periods and the auto-regressive error terms AR(i) -, will be presented in a double logarithmic form. Monthly minimal wage, price, and meat quantity data used in the research were obtained from Anualpec (1988). Monthly data of the general price index (GPI-DI) were provided by the Getulio Vargas Foundation (1991-1998).

SUR model for the demand equations:

$$\begin{bmatrix} \ln QCB_t \\ \ln QCF_t \\ \ln QCS_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} + \begin{bmatrix} \eta_{11} & \eta_{12} & \eta_{13} & \eta_{r1} \\ \eta_{21} & \eta_{22} & \eta_{23} & \eta_{r2} \\ \eta_{31} & \eta_{32} & \eta_{33} & \eta_{r3} \end{bmatrix} \cdot \begin{bmatrix} \ln PCB_t \\ \ln PCF_t \\ \ln PCS_t \\ \ln SM_t \end{bmatrix} + \begin{bmatrix} \varphi_1 & \rho_{1i} \\ \varphi_2 & \rho_{2i} \\ \varphi_3 & \rho_{3i} \end{bmatrix} \cdot \begin{bmatrix} VD \\ AR(i) \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$$

This model's estimates are subject to tests of hypothesis on serial auto-correlation of the error terms of each demand equation participating in the system, as well as subject to tests of the symmetry and homogeneity hypotheses.

RESULTS AND DISCUSSION

This section presents the results obtained for the statistical tests of serial auto-correlation and those of the symmetry and homogeneity hypotheses, which were conducted to better specify the SUR model, proposed to estimate the meat demand system in Brazil, during the 1990-1997 period. The complete SUR model results will also be presented.

Auto-correlation tests

The Durbin-Watson test shows the presence of positive serial auto-correlation in the three equations' residuals, since the value 95 g.l. of the inferior limit of figure d is 1.579 at a 5% probability and is higher than the values found for the demand equations (Table 2). The statistics F and $n.R^2$ show that the beef, chicken, and pork meat equation error terms are auto-correlated of first order, third order, and second order, respectively (Table 2). Thus, the SUR model was restructured to include the auto-regressive terms in the equations.

Table 2- Result of test for autocorrelation of the SUR model demand equation residual, Brazil, 1991/1997

Estatistics	***Meat demand equations***		
	Beef	Chicken	Pork
Durbin-Watson test - ***d***	0.8645	0.9831	0.9802
Autoregressive coefficient - ρ			
Frist order – *AR(1)*	0.5774	0.4133	0.4583
Second order – *AR(2)*	-	0.3427	0.2145
Third order – *AR(3)*	-	0.1018	-
Eviews statistical tests			
Statistics F	41.8261	17.4887	18.1994
Statistics $(n.R^2) \sim \chi^2$	30.6919	36.1145	28.0894
Probability	0.0000	0.0000	0.0000

Source: research results.

The results obtained from the contemporaneous correlation of the error terms between the equations are different from zero and high, as shown by data on the matrix of residual correlation (Table 3), which justifies the adequation of the seemingly unrelated equation model. These results, together with those of serial correlation justify the use of the generalized least squares method for estimating the model.

Table 3- Matrix of residual correlation of the SUR model, Brazil, 1990/ 1997.

Equation	***ln QCBt***	***ln QCAt***	***ln QCSt***
ln QCBt	1.00000		
ln QCAt	-0.18510	1.00000	
ln QCSt	0.65078	-0.09790	1.00000

Source: research results.

Hypothesis tests

Table 4 shows that only the homogeneity restriction for income-elasticity is valid at 5% probability (Table 4). Thus, the autoregressive SUR model to be estimated will include this restriction.

The rejection of the remaining hypotheses is not surprising since aggregate demand is not dependent on such assumptions. Although being a sufficient condition for individual demand, such properties represent just a condition necessary to determine the function of aggregate demand.

Table 4- Wald test results for symmetry and homogeneity restrictions of the meat aggregate demand system in Brazil, 1990/1997

Hypothesis	*Wald test* - λ_w	Probability
Symmetry hypothesis in the autoregressive model		
Cross-elasticities: $\eta_{ij} = \eta_{ji}$	6.585	0.0863
Homogeneity hypothesis		
Price and income elasticities: $\Sigma\eta_{ij} + \eta_{ir} = 0$	2.917	0.4045
Income-elasticities: $\Sigma\eta_{ir} = 1$	178.878	0.0000

Source: Research results.

SUR model results

The results obtained from the estimation of the Marshallian meat aggregate demand system are shown in Table 5.

The parameter signs are in agreement with the consumer theory and are different from zero at 5% probability, except for the coefficients of the variables beef and pork meat prices in both the chicken and pork equations. The explanatory power of the exogenous variables is said to be good when, evaluated by the fitted determination coefficient, it is higher than 54% in the beef meat equation, higher than 81% in the chicken meat equation, and higher than 77% for the pork meat equation. The coefficient of the variable dummy (crop period equal to 1 and intercrop period equal to 0) was negative for the three equations, but it was not different from zero for the beef meat equation. This behavior shows that in the absence of the variable dummy, the autonomous consumption of meat would be overestimated. The serial auto-correlation of the error terms has disappeared, and the estimation of the model by generalized least squares (full information maximum likelihood) has gained asymptotic efficiency.

The model was estimated in natural logarithms; thus, elasticities can be read directly from Table 5 results.

Price-elasticities are of - 0.271, - 0.332, and zero order, respectively, for beef, chicken, and pork meats. This means that beef and chicken meat demands are price inelastic while pork demand is perfectly inelastic. For 10% variations in the prices of chicken and beef, the quantity demanded varies conversely, about 3.32% and 2.71% respectively. As a consequence of specific chicken meat price increases, beef and pork demands also vary conversely, 2.84% and 4.0% respectively. As chicken meat demand is not influenced by beef and pork variations, it is accepted to be the meat that signals, enhances, and promotes adjustments in the Brazilian market for meat.

In regard to income-elasticities, the following results were obtained: 0.195 for beef, 0.393 for chicken, and 0.413 for pork. This shows that a consumer income variation of 10% can cause the same direction differentiated displacements of 4.13%, 3.93%, and 1.95% in pork, chicken, and beef demands, respectively. This permits these three meats to be classified as essential food products for the Brazilian people .

In regard to cross-elasticities, which are the main focus of this research, chicken is found to be complementary to beef and pork. The latter is a substitute for beef and independent from chicken. Beef has showed itself to be independent from the other two meats. These results are sufficient to validate the hypothesis that meat demand cross-relationship have changed in Brazil, in agreement with worldwide trends.

Table 6 data show the change which occurred in the relations of substitutability between beef, chicken, and pork in Brazil, before and after the 1980s. It is also possible to compare the current Brazilian situation (1990s) with the results found for the United States, Canada, Australia, Japan, and the European Union.

Besides the reversion in cross-elasticity signals - when chicken stopped being a substitute for beef and pork and became complementary in the 1990s – there was also a remarkable change in the coefficients of price-elasticity and income-elasticity. With regard to income-elasticity, beef and pork were no longer found to be luxury goods and become essential in the Brazilian diet. Moreover, chicken meat demand became more income-elastic. With regard to price-elasticities, it should be noted that demands became more inelastic, especially chicken and pork meat demands.

An explanation for changes in direct income-elasticities and price-elasticities is the significant fall in the real price of beef (-19.61%), chicken (-27.06%), and pork (-5.68%) between 1990 and 1997, as well as the change in the minimum wage, which increased 44.56% on average. In other words, the relative expense involved in the acquisition of these products decreased, especially for the low income classes, with beef and pork demands becoming more price and income inelastic. Two reasons chicken demand became more elastic when compared with beef and pork demands was value aggregation and, above all, marketing programs, which characterized chicken as a high quality food, well suited for people with heart and obesity related diseases.

Table 5 - Results for the meat demand system in Brazil, 1990/1997

Estimation Method: Full Information Maximum Likelihood				
Equation 1: Beef – ln QCB_t				
Exogeneous variable	Coefficient	Std. Error	Statistics - t	Prob.
Constant - α_{10}	12.15008	0.128320	94.68552	0.0000
ln PCBt - η_{11}	-0.271008	0.092878	-2.917890	0.0038
ln PCFt - η_{12}	-0.283880	0.053681	-5.288280	0.0000
ln PCSt - η_{13}	0.287824	0.088675	3.245841	0.0013
ln SMt - η_{1r}	0.194563	0.033957	5.729621	0.0000
VD - φ_1	-0.022993	0.020803	-1.105257	0.2701
AR(1) - ρ_1	0.513190	0.083321	6.159229	0.0000
R-squared	0.570602	Mean dependent variable		13.09531
Ajusted R-squared	0.541325	S.D. dependent variable		0.098746
S.E. regression	0.066876	Sum squared resid		0.393574
Durbin-Watson *(d)*	1.808889			
Equation 2: Chiken – ln QCA_t				
Constant - α_{10}	10.27922	0.505757	20.32442	0.0000
ln PCBt - η_{11}	-0.053700	0.155457	-0.345436	0.7300
ln PCFt - η_{12}	-0.332142	0.088374	-3.758382	0.0002
ln PCSt - η_{13}	0.203265	0.127185	1.598183	0.1112
ln SMt - η_{1r}	0.393237	0.058705	6.698494	0.0000
VD - φ_2	-0.073470	0.032679	-2.248196	0.0254
AR(1) - ρ_1	0.412694	0.112168	3.679253	0.0003
AR(2) - ρ_2	0.362792	0.107558	3.372981	0.0009
AR(3) - ρ_3	0.039931	0.106813	0.373837	0.7088
R-squared	0.826924	Mean dependent variable		12.53255
Ajusted R-squared	0.810441	S.D. dependent variable		0.216516
S.E. regression	0.094268	Sum squared resid		0.746455
Durbin-Watson *(d)*	1.976397			
Equation 3: Pork – ln QCS_t:				
Constant - α_{10}	9.147919	0.265181	34.49686	0.0000
ln PCBt - η_{11}	-0.012032	0.115270	-0.104381	0.9169
ln PCFt - η_{12}	-0.399882	0.077563	-5.155589	0.0000
ln PCSt - η_{13}	0.197996	0.127760	1.549748	0.1224
ln SMt - η_{1r}	0.413100	0.048280	8.556341	0.0000
VD - φ_3	-0.118713	0.027777	-4.273863	0.0000
AR(1) - ρ_1	0.490472	0.096164	5.100372	0.0000
AR(2) - ρ_2	0.218259	0.095979	2.274016	0.0238
R-squared	0.792251	Mean dependent variable		11.61998
Ajusted R-squared	0.772698	S.D. dependent variable		0.175178
S.E. regression	0.083518	Sum squared resid		0.592901
Durbin-Watson *(d)*	2.068929			
Log Likelihood		370.6842	Relative to the demand	
Determinant residual covariance		9.56E-08	system	

Source: Research results.

The changes in meat demand cross-relations were clearly due to the new food consumption dynamic, which emphasized foods of more added value, higher quality and safety, and eaten outside the home. Recently, Park & Capps Jr. (1997) have shown that in United States processed food is complementary to other meals and to substitute meals eaten outside the home. In Brazil, over the period 1987/1988 to 1995/1996, the processed food expenses of low income consumers have increased relative to their eating out expenses, and middle and high-income consumers' processed food expenses have slightly decreased relative to their eating out expenses (Table 7). On the other hand, during the same period, processed food expenses substantially increased when compared to *in natura* food expenses for all income groups.

Such results support this work's hypothesis, in that the new consumption trend has induced industries to modernize to meet consumer needs for higher value added processed food and for eating out. Since chicken meat has revolutionized the market in terms of value aggregation, diversification, and in meeting consumer desires when compared to the other types of meat, it has become complementary to these other meats, i.e., more chicken meat is consumed with other meats.

A comparison of the results obtained in this study with the results from similar recent studies of other countries shows that changes in the substitutability relations found between chicken, beef and pork have been occurring worldwide, as shown in data on the United States, Canada, Australia, Japan, and the European Union (Table 6). Chicken is found to be complementary to beef in Brazil and Japan, to pork in Brazil and the United States, and to mutton in Australia. In Japan, beef is also complementary to chicken. In addition, data show that beef and chicken are independent in Australia, the United States, and Canada because the elasticity coefficients are not statistically different from zero, although the signal is negative. In the European Union, crustaceans are complementary to frozen salmon.

The interesting fact about these results is that no research has attempted to justify the reasons for such deviations from the expected, stating only that the results obtained were in opposition to what was anticipated. EU studies do not even make any reference to the complementarity found between crustaceans and frozen salmon. This is, therefore, a distinguishing aspect of our analyses.

Finally, how should Brazil's economic agents absorb and apply such results? What is their implication for Brazilian agricultural policy?

Firstly, the strategies applied by some economic agents should be drastically changed with respect to the pursue of domestic competition, i.e., in this current consumption dynamic, complementarity has taken place as a function of the distancing of the avian segment from the other meat segments. The avian segment has adding more value to chicken meat and diversified product lines so as to adequately meet the needs of consumers.

This means that the Brazil's beef and pork meat industrial segments will have to advance in the same direction by reducing margins, investing in quality, diversifying meat product lines, and improving marketing strategies to meet and stimulate consumer needs, following the same standards of the chicken meat industry. Otherwise, it will be difficult to maintain their share of the domestic, animal protein market.

Another important implication for policy makers is that they will have to review the methods and formulas applied to demand dimensioning, consumption planning, and food provision program design.

Table 6- Meat price and income-elasticity coefficients in Brazil, the United States, Canada, Australia, Japan, and the European Union; 1990/1997

Types of meat	η_r	*Price-elasticity* - η_{ij}		
		Beef	***Chicken***	***Pork***
Research results-Brazil				
Beef	0.195	-0.271	-0.054 *ns*	-0.012 *ns*
Chicken	0.393	-0.284	-0.332	-0.400
Pork	0.413	0.288	0.203 *ns*	0.198 *ns*
Other results – Brazil	η_r	***Beef***	***Chicken***	***Pork***
Beef	1.050	-0.290	0.190	0.100
Chicken	0.130	0.840	-0.700	-
Pork	1.190	0.340	0.530 *ns*	-0.190
Results – United States	η_r	*Beef*	*Chicken*	*Pork*
Beef	0.326	-0.302	0.068	0.240
Chicken	0.354	0.022 *ns*	-0.102	-0.018
Pork	0.211	0.148	0.024 *ns*	-0.287
Results - Canada	η_r	***Beef***	***Chicken***	***Pork***
Beef	1.075	-0.885	0.002 *ns*	0.191
Chicken	0.766	0.156 *ns*	-0.804	-0.119
Pork	1.021	-0.264 *ns*	-0.115	-0.641
Results - Australia	η_r	***Beef***	***Chicken***	***Mutton***
Beef	1.822	-0.421	0.336 *ns*	0.679
Chicken	0.177 *ns*	-0.143 *ns*	-0.463	-1.259
Mutton	0.426	0.431	-0.104 *ns*	-0.472
Results - Japan	η_r	***Beef***	***Chicken***	***Fish***
Beef	2.490	-0.290	-0.150	0.020
Chicken	1.600	-0.240	-0.420	0.090
Fish	0.790	0.130	0.490	-0.240
Results – European Union	η_r	***Fresh salmon***	***Frozen salmon***	***Crustacean***
Fresh salmon	0.239	-3.728	1.373	0.778
Frozen salmon	0.454	2.757	-2.569	0.297
Crustacean	1.661	0.204	-0.020	-1.557

Source: research results. Fernandes et al. (1989), Silva et al. (1997), Hayes (1990), Moschini & Vissa (1993), McNulty & Huffman (1992), Piggott et al. (1996). *ns* = non-significant. η_r = income-elasticity.

Table 7- Household food expenses in São Paulo, by income level 1995/ 1996.

Expenditure categories	*Low income Up to 5 MW*	*Medium income From 5 to 20 MW*	*High income 20 MW and up*
Processed food/food eaten out			
Brazil – 1995/96	6.22	3.03	2.35
Brazil – 1987/88	5.07	3.35	2.39
Processed food/*in natura* food			
Brazil – 1995/96	2.44	2.40	3.49
Brazil – 1987/88	1.36	1.92	2.69

Source: IBGE (1989, 1997). MW= minimal wage.

CONCLUSIONS

This work is part of a research area which has been neglected in Brazil over the recent decades. Contrary to trivial analysis, its results open up new paths to guide the decision making process of economic agents willing to enter the meat business and policy makers' studies of demand dimensioning, consumption prediction, and program guidance.

The main conclusions of this research were:

a) chicken meat is no longer a beef and pork substitute, having become a complementary product to beef and pork in the Brazilian market. The reason for this is the restructuring of the food industry to meet consumer desire for processed food and their growing inclination to eat out.

b) beef and pork are no longer luxury goods, having become an integral part of the Brazilian consumer's diet due to a fall in meat prices and a rise in consumer incomes during the period under analysis.

c) Chicken and beef demands were price-inelastic and pork demand was perfectly price-inelastic during the period under analysis.

d) Chicken meat demand is not influenced by beef and pork price variations but imposes strong changes in such demands so as to signal and/ or induce the adjustment of the Brazilian meat market.

REFERENCES

AGRIANUAL. ***Anuário da agricultura brasileira***. São Paulo: FNP, 1999.

AGROANALYSIS. Rio de Janeiro, v.18, n.2, 5 e 10, 1998.

ANUALPEC. ***Anuário da pecuária brasileira***. São Paulo: FNP, 1998.

BRANDT, S.A. ***Comercialização agrícola***. Piracicaba: Livroceres, 1980.

CONJUNTURA ECONÔMICA. Rio de Janeiro, v.46/52, n.11, 1991/1998.

DEATON, A.S., MUELLBAUER, J. An almost ideal demand system. ***American Journal of Agricultural Economics***, v.70, n.2, p.312-26, 1988.

EVIEWS. ***User's guide***. Irvine: QMS, 1998. Versão 3.0.

FERNANDES, S.A. PANIAGO, E., LIMA, J.E. Análise de políticas relacionadas com a demanda e a oferta de carnes no Brasil. ***Revista de Economia e Sociologia Rural***, v.27, n.4, p.437-61, 1989.

GREENE, W.H. ***Econometric analysis***. 3 ed. London: Prentice-Hall, 1997.

HAYES, D. J. WAHL, T.I., WILLIANS, G.W. Testing restrictions on a model of Japanese meat demand. ***American Journal of Agricultural Economics***, v.72, n.3, p.556-566, 1990.

IBGE. ***Pesquisa de orçamentos familiares – 1987/88***. Rio de Janeiro: Fibge, 1989.

IBGE. ***Pesquisa de orçamentos familiares – 1995/96.*** Rio de Janeiro: Fibge, 1997.

JACOBY, B.G., SKOUFIAS, E. Testing theories of consumption behavior using information on aggregate shocks: income seasonality and rainfall in rural India. ***American Journal of Agricultural Economics***, v.80, n.1, p.1-14, 1998.

JUDGE, G.G. GRIFFITHS, W.E., HILL, R.C., LÜTKEPOHL, H., LEE, T-C. ***The theory and practice of econometrics***. 2 ed. New York: John Wiley and Sons, 1985.

KMENTA, J. ***Elementos de econometria***. São Paulo: Atlas, 1978.

MADDALA, G.S. ***Econometrics***. Singapore: McGraw-Hill, 1988.

MARTINELLI Jr., O. ***As tendências recentes da indústria de alimentos:*** um estudo a partir das grandes empresas. Campinas: Unicamp, 1997. (Tese de doutorado).

McDOWELL, D.R. et al. Food expenditures and socioeconomic characteristics: focus on income class. ***American Journal of Agricultural Economics***. v.79, n.5, p.1444-51, 1997.

McNULTY, M. S., HUFFMAN, W.E. Trading-day variation: theory and implications for monthly meat demand. ***American Journal of Agricultural Economics***, v.74, n.4, p.1002-1009, 1992.

MOSCHINI, G., VISSA, A. Flexible specification on mixed demand systems. ***American Journal of Agricultural Economics***, v.75, n.1, p.1-9, 1993.

PARK, J.L. HOLCOMB, R.B., RAPER, K.C., CAPPS Jr., O. A demand system analysis of food commodities by U.S. household segmented by income. ***American Journal of Agricultural Economics***, v.78, n.2, p.290-300, 1996.

PARK, J.L., CAPPS Jr., O. Demand for prepared meals by U.S. households. ***American Journal of Agricultural Economics***, v.79, n.3, p.814-824, 1997.

PIGGOTT, N.E. CHALFANT, J.A., ALSTON, J.M., GRIFFITH, G.R. Demand response to advertising in the Australian meat industry. ***American Journal of Agricultural Economics***, v.78, n.2, p.268-79, 1996.

ROSEGRANT, M.W., SOMBILLA, M.A. Critical issues suggested by trends in food, population, and the environment to the year 2020. ***American Journal of Agricultural Economics***, v.79, n.5, p.1467-70, 1997.

SANTANA, A.C. Estrutura de mercado e análise de políticas na pecuária de corte do Estado do Pará. In: Aguiar, D.R.D., Pinho, J.B. (Ed.) ***O agronegócio brasileiro:*** desafios e perspectivas. Brasília: SOBER, 1998. p.637-652.

SANTANA, A.C. ***Métodos quantitativos em economia***. Belém: FCAP, 1998.

SANTANA, A.C. D'ÁVILA, J.L., ALENCAR, M.I.R., MATTAR, P.N. SOUZA, R.F. COSTA, R.M.Q. ***Reestruturação produtiva e desenvolvimento na Amazônia:*** condicionantes e perspectivas. Belém: BASA; FCAP, 1997.

SANTANA, A.C., SILVA, M.C. ***Cadeia produtiva do café:*** análise de mercado e avaliação de políticas. Belém: SAGRI; FCAP - Imprensa Oficial, 1998. 52p.

SILVA, G.L.S.P., TOYAMA, N.K., YOSHII, R.J. Oferta e demanda de frango no Estado de São Paulo. ***Revista de Economia Rural***, v.15, n.1, p.193-207, 1977.

SIMONSEN, M.H. ***Teoria microeconômica***. 9 ed. Rio de Janeiro: FGV, 1987.

VARIAN, H.R. ***Microeconomic analysis***. 2 ed. New York: Norton, 1984.